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A

REPORT

ON

MICROSCOPICAL AND PHYSIOLOGICAL RESEARCHES

INTO THE

NATURE OF THE AGENT OR AGENTS PRODUCING

CHOLERA

(SECOND SERIES)

BY

T. R. LEWIS, M.B., AND D. D. CUNNINGHAM, M.B.,

SURGEON, H.M. BRITISH MEDICAL SERVICE, SURGEON, H.M. INDIAN MEDICAL SERVICE,

(ON SPECIAL DUTY)

ATTACHED TO THE SANITARY COMMISSIONER WITH THE GOVERNMENT OF INDIA.

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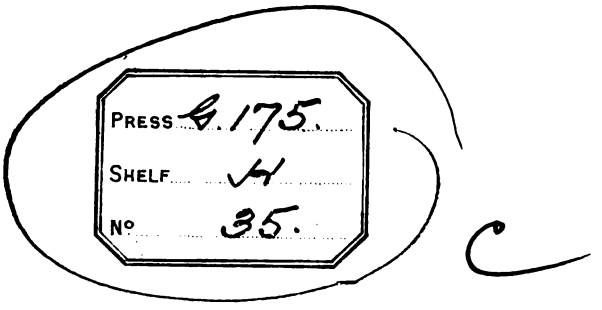
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PART I.

MICROSCOPIC EXAMINATIONS OF BLOOD.

Reason for further examinations of blood.

The question of the microscopic characters presented by the blood in cholera is reverted to in the present report, not because we have to make any material modifications in our former statements, or to record any additional phenomena of any great importance, but as the features previously described as characterising the blood in this disease were by no means such as the views, at present widely prevalent, relative to the causes and methods of diffusion of epidemic disease would have led us to expect, it has been considered advisable to examine the question very carefully again.

Methods of research.

Before entering on the discussion of the phenomena of any morbid condition, as we have previously pointed out, it is manifestly requisite that a healthy standard with which they may be compared should be obtained, and, if any important deviations from this standard be observed, these again must be compared with those which occur in connection with other diseased conditions. This method of observation has been followed in the present instance, and the results are stated in similar

* Being one of the Appendices to the *Tenth Annual Report of the Sanitary Commissioner with the Government of India.*

order—the standard phenomena of healthy blood being considered first, those of the disease specially under investigation next, and finally those of various other (ordinary and artificially induced) diseased conditions.

Nature of observations.

The methods of examination were precisely the same as those previously employed and described, and consisted in the use of ordinary preparations, preparations which had been exposed to the fumes of osmic acid, and preparations mounted in wax cells for purposes of continued observation. The microscopic powers employed were the $\frac{1}{6}''$ and $\frac{1}{12}''$ immersion objectives of Ross; and the $\frac{1}{16}''$ and $\frac{1}{25}''$ immersion lenses of Powell and Lealand. We have found the $\frac{1}{16}''$ object glass of the latter makers, and the $\frac{1}{6}''$ of Ross, particularly suitable for investigations of this kind, especially when used *à immersion*.

Wax cells afford the conditions necessary for the development of bacteria, &c.

In connection with the employment of wax cells in continued observations, renewed experiment was made in regard to their affording the conditions necessary for the development of bacteria or fungal elements, if these were really present. The results agreed with those previously recorded,* preparations of blood inoculated with fluid containing bacteria being quickly decomposed with abundant development of these organisms, and specimens in which one or more of the common atmospheric spores had been enclosed being rapidly dried up by the growth of mycelial filaments, which in many instances produced an abundant crop of their characteristic fructifications. With these preliminary observations we may proceed to a detailed account of our experiments and their results.

---

* Eighth Annual Report of the Sanitary Commissioner with the Government of India—Appendix B, p. 154, 1872.

Ninth Annual Report of the Sanitary Commissioner with the Government of India—Appendix A, pp. 37-38, 1873.

A.—Microscopic examinations of the Blood in Health.

The following table shows the characters of eighteen specimens of the blood of healthy subjects, the first fourteen being derived from the human subject, the last four from healthy dogs:—

TABLE I.

Microscopic characters of Normal Blood.

No of case.	No.	Serum.	Red corpuscles.	White corpuscles.	Molecular matter.	Bacteria.	Fungi.	Remarks.
I	1	Clear	Normal ...	Few ...	None ...	None...	None...	Numerous bacteroid appearances, due to decomposition of cover glass. (*Vide* page 4.)
„	2	„	„	„	„	„	„	
„	3	„	„	„	„	„	„	
II	4	„	„	„	„	„	„	After some days the white corpuscles discharged their contents and remained as hyaline spheres.
„	5	„	„	„	„	„	„	Inoculated with bacteria, and in 48 hours quite decomposed.
III	6	„	Echinulated	„	„	„	„	This was a very thin layer spread out by pressure on the cover.
„	7	„	Normal ...	„	Sprinkling of motile points.	„	„	Numerous glass bacteria: no pressure applied.
IV	8	„	Echinulated on pressure.	„	Very few...	„	„	Echinulation produced and increased at will by pressure.
V	9	„	Normal ...	„	Sprinkling	„	„	Echinulation appearing on pressure; numerous delicate fibrinous threads in the serous spaces.
„	10	„	„	„	„	„	„	Ditto ditto ditto.
VI	11	„	„	„	None ...	„	After 3 days.	
„	12	„	„	„	„	„	None...	No fungi appeared in this at any time.
VII	13	„	„	„	Sprinkling	„	„	Blood from the heart of a dog.
VIII	14	„	„	„	Very few...	„	„	Ditto ditto.
IX	15	„	„	„	None ...	„	„	Blood from the liver of a dog.
„	16	„	„	„	„	„	„	
„	17	„	Echinulated	„	„	„	„	
X	18	„	Normal ...	„	„	„	„	
X	18	...	.....	...	6	...	1	

The features presented in this table, which require special consideration, appear to be the following: the occurrence of echinulation in the red corpuscles, the liberation of granular matter from the white ones, the presence of motile points, fibrinous threads and fungi, and finally, the deceptive appearances due to decomposition of the glasses employed in the preparations.

Stress laid by authors on echinulation of the red corpuscles.

1. *The echinulation of the red corpuscles.*—This is a phenomenon which has been so long recognised that it would have been unnecessary to notice it here had not considerable stress been laid upon its presence by various recent writers on pathological histology. We find MM. Coze

and Felz describing the red corpuscles presenting "l'aspect d'un chaton de marron d'Inde;" and appearing "comme recouverts de piquants qui rappellent très-bien la forme de bâtonnets ou Bactéries," as one of the characteristics of the blood in septicæmia, typhoid, variola, and measles, and suggesting the possibility of such appearances being due to the development upon the red corpuscles of the bacteria which they affirm to be the cause of the diseases in question.*

The phenomenon may be induced by pressure,

It is no doubt true that a phenomenon like that of echinulation may be induced by various causes, and that some of these causes may be morbid conditions of the blood; still there is very great need of caution in interpreting the significance of any phenomena which we find may co-exist with health in the subjects furnishing the specimens under examination, nay more, which may be induced accidentally or at will by slight modifications in manipulation. Now, we have no hesitation in affirming that this is the case in regard to the phenomenon under consideration, and, although at first inclined to ascribe some importance to its presence, we have in the course of experience come to regard the whole matter with grave suspicion. Numerous experiments clearly showed that echinulation was the invariable consequence of employing a very small quantity of blood so as to spread it out in a very thin layer (*vide* No. 6, Table I), or of pressure wilfully applied to thicker layers (*vide* Nos. 8 and 9 of the same table).

and by other means.

That other influences beyond mere mechanical pressure do, however, result in producing similar appearances was clearly manifest in one or two cases in which the phenomenon came on gradually in specimens preserved in wax cells in which there could certainly be no pressure on the corpuscles, beyond that of the contained air; nor could the evaporation have been sufficient to have accounted for the alteration. However induced, the condition appeared in one of two forms; to the first of these, in which the corpuscles appeared beset with very fine projecting points, the term 'echinulation' is strictly applicable; whilst in the other 'tuberculation' more accu-

* "Recherches cliniques et expérimentales sur les maladies infectieuses étudiées spécialement au point de vue, de l'état du sang et de la présence des ferments."—Paris, J. B. Balliére et Fils, 1872. p. 76.

rately represents the condition, for the corpuscles, instead of presenting their normal smooth outline, were covered with obtuse projections of various sizes. Both forms were commonly present in one and the same sample, although one or other usually predominated.

Molecular matter due to disintegration of white corpuscles.

2. *The liberation of granular and molecular matter from the white corpuscles.*—This process, occurring almost invariably in specimens of blood subjected to continued observation, was fully described in the previous report, and we now again call attention to it merely in order to reiterate the statement that such granules and molecules might very easily be supposed to be extraneous particles of bacteroid nature, were not their source and process of liberation clearly demonstrated by continuous observation of individual specimens.

Probable nature of the motile particles.

3. *Motile particles.*—It will be seen that these were observed in six samples of blood from five cases, and when present they formed a characteristic feature. They were excessively minute solitary points, just visible under the highest powers employed, and in incessant active motion in the serous spaces among the corpuscles. They were present in the blood immediately on its removal from the body, underwent no farther development in specimens retained under observation, but on the contrary usually disappeared within a short time. Their nature could not be satisfactorily determined, but they certainly showed no evidence of being organized, and their motion, although very energetic, may very probably have been purely mechanical, as particles of such excessive minuteness must naturally tend to move actively for some time, when the fluid containing them is subject to so much disturbance as is involved in procuring and mounting specimens of it for examination. The chief point of importance in regard to them is, that bodies of such a nature may occasionally be detected in the blood of individuals apparently in perfect health.

Evanescent character of fibrinous threads.

4. *Fibrinous threads.*—In two of the specimens of the table, delicate fibrinous threads were numerous, crossing the serous spaces between the corpuscles. We have observed that threads of

this nature very soon disappear, and in these particular preparations they were not visible after an interval of twenty-four hours.

Absence of bacteria.

5. *Bacteria.*—Distinct bacteria were observed in no instance either as actually present in the specimens immediately on their removal from the body, or as being developed in them during the time in which they were retained under observation—a time varying from a few days to several months.

Absence of fungi.

6. *Fungi.*—In only one instance were fungi developed in a specimen whilst under observation; but, as the forms which were developed in this instance were those belonging to ordinary atmospheric spores, and as only one of two specimens simultaneously obtained from the same individual was affected, the presumption is that they were due merely to accidental contamination, and not to the presence of any inherent fungal elements in the blood.

Spectral bacteria.

7. *Phenomena dependent on imperfections in the glass of slides and covers.*—It will be seen that in four specimens numerous bacteroid bodies were present, which were traced to imperfections in the surface of the glasses employed to mount the specimens. It may appear unnecessary to enter into any detailed discussion of such appearances, but as we were for a considerable time somewhat misled by such appearances, and as it seems very probable that other observers, on whose observations great reliance has been placed, have been similarly misled, we consider that a brief account of such fallacious appearances—which we propose to call 'spectral bacteria'—may not be amiss.

Milky spots.

In describing preparations of blood and of choleraic fluids in previous reports reference has more than once been made to the appearance of "milky spots," * and it was in working with such specimens that the phenomena due to slight erosions of glass surfaces in contact with viscid fluids were first clearly recognised. It was casually observed that the cover-glass in a particular specimen, which showed these milk

* Ninth Annual Sanitary Report, App. A, p. 26.

spots in considerable numbers, had been slightly affected with that form of surface decomposition which so rapidly renders thin glass useless for microscopic work in this country, ultimately converting it into a whitish translucent medium like ground glass. Attention having been attracted to this as a possible explanation of the previously unaccountable "milk spots," numerous experiments were tried with glasses affected in various degrees with surface erosions, and a great variety of extremely deceptive appearances were traced to the existence of such a condition either in the cover-glasses or in the slides employed. When the erosions were comparatively large, they gave rise to appearances simulating cellules of various sizes; whilst when very minute, spectral molecules, monads, and bacteria were produced. Some of the bacteroid markings were peculiarly deceptive, consisting of oblong or rod-like appearances separated from one another by what seemed to be joints. All these spectral cellules, microzymes, and bacteria are of course motionless, although a slight movement may sometimes *appear* to occur, due to imperceptible changes in the position of bodies, such as blood corpuscles, in the preparation affected.

How to be distinguished from solid bodies.

These appearances are to be recognised in one or other of two positions in the preparation, coming into focus either before, which is much more common, or after the real solid bodies contained in the fluid. For example, in a preparation of blood they are either found immediately beneath the cover-glass, coming into view before the red corpuscles are defined, or more rarely at the bottom of the preparation after the corpuscles have lost their sharpness of outline. When present in small numbers only, they are frequently exceedingly deceptive, more especially those of the upper layer, when, as is sometimes the case, they are interspersed among real solid particles; but there is one infallible means of distinguishing them, for all such spectra first make their appearance as *shaded bodies, becoming bright as the focus is deepened,* often, more especially when of some size, assuming a pinkish tinge whilst doing so, *and passing out of view as bright spaces.* Now, as these phenomena are just the reverse of those occurring in the case of actual solid particles, such as bacteria, which appear *first as bright points* becoming *shaded on deepening the focus,* they may always be distinguished by a

little careful examination, but at the same time they easily deceive if a preparation be but cursorily examined. Such appearances are, very probably, much less liable to be met with in other climates where glass surfaces are not so prone to decomposition, but the possibility of their occurrence should always be borne in mind.

The "zone immobile" recently described as being in the blood in various diseases, evidently identical in character with the "spectral bacteria" here described.

This idea particularly suggests itself in connection with the importance which MM. Coze and Felz attach to the occurrence of a "zone immobile" of bacteria, in specimens of blood in various infectious diseases. These authors say in reference to this point:—"Dans cet examen microscopique, une circonstance nous a frappés, et nous n'avons trouvé le fait consigné nulle part. En tournant la vis du microscope pour mettre l'instrument au point, on aperçoit comme un semis de corpuscles tout à fait immobiles et assez rapprochés les uns des autres. Le semis paraît tantôt, et le plus souvent, fixé a la partie interne de la plaque recouvrante, tantôt, plus rarement, à la plaque inférieure, * * * cette zone a été également signalée tout récemment par Davaine." The appearance of this "zone immobile" agrees very closely with that due to glass erosions, and it is manifest that the latter might very easily be mistaken for or confounded with organic particles.

Sarcinæ.

8. As regards the alleged constant presence of sarcinæ or their elements in the blood, we have only to repeat our former statement that our observations (and this applies as well to morbid as to healthy specimens) have not afforded it the slightest confirmation, so that, in so far as this country at all events is concerned, it appears to be wholly unfounded.

B.—Microscopic examinations of the Blood in Cholera.

The following table shows the results of the examinations of forty-one specimens of blood from twenty-two cases of cholera:—

TABLE II.

Microscopic characters of Choleraic Blood.

No. of case.	No.	Serum.	Red corpuscles.	White corpuscles.	Bacteria.	Fungi.	Remarks.
I	1	Clear, abundant.	Normal ...	Very abundant.	None ...	None ...	
„	2	„	„	„	„	„	
„	3	„	„	Few ...	„	„	
II	4	„	„	Very abundant.	„	„	
III	5	„	Echinulate	„	1 or 2 after 3 days.	„	
„	6	„	Normal ...	„	None ...	„	
IV	7	„	„	„	„	„	
„	8	„	„	„	„	„	
V	9	„	„	„	„	„	
„	10	„	„	„	„	„	
VI	11	„	Very diffluent.	„	„	After 8 days	Delicate fibrinous threads in the serous spaces.
VII	12	„	Normal ...	Abundant...	„	„	
VIII	13	„	„	Normal ...	„	„	Patient not in collapse: attack very slight.
„	14	„	„	„	„	„	
IX	15	„	Diffluent ...	Abundant...	„	„	Fibrinous threads present.
„	16	„	„	„	„	„	Ditto ditto.
X	17	„	Normal ...	„	„	„	
„	18	„	„	„	„	„	
„	19	„	„	„	„	„	Fibrinous threads present.
XI	20	„	„	„	„	„	Ditto ditto.
„	21	„	„	„	„	After 15 days	Ditto ditto.
XII	22	„	Diffluent ...	„	„	„	
„	23	„	„	„	„	„	Fibrinous threads present.
XIII	24	„	„	„	„	„	Ditto ditto.
„	25	„	„	„	„	„	Common preparation.
XIV	26	„	Very diffluent.	Sprinkling	„	„	Wax cell preparation.
„	27	„	Diffluent ...	Abundant...	„	„	
XV	28	„	„	Sprinkling	„	„	
„	29	„	„	„	„	„	
XVI	30	„	„	Abundant...	„	„	Fibrinous threads present.
„	31	„	„	„	„	„	
XVII	32	„	Very diffluent.	Very abundant.	„	„	Ditto ditto.
„	33	„	„	„	„	„	
„	34	„	„	„	„	„	
XVIII	35	„	Diffluent ...	Abundant...	„	„	Fibrinous threads present.
„	36	„	„	„	„	„	Ditto ditto.
XIX	37	„	Normal ...	Normal ...	„	„	
XX	38	„	„	Abundant...	„	„	Fibrinous threads present.
„	39	„	„	„	„	„	Ditto ditto.
XXI	40	„	Very diffluent.	Sprinkling	„	„	
XXII	41	„	Diffluent ...	Abundant...	„	„	

The condition of the red corpuscles in cholera.

It will be seen that the results here recorded are almost identical with those of the former report; showing the same absence of bacteria, fungi, or other extraneous

bodies; and the same general prevalence of considerable leucocytosis. There is one phenomenon, however, prominently noted in this instance which was not adverted to previously, and that is the diffluent condition of the red corpuscles. This was observed in no less than twenty instances, the condition being very strongly pronounced in four of these. It showed itself in a tendency manifested by the corpuscles to aggregate in irregular masses in place of forming the normal rouleaux;* and, in ordinary preparations where any pressure was exerted, and in which there was any movement of the fluid, in the ease with which the corpuscles altered their forms, were drawn out into irregular processes or adhered to one another by elastic protrusions. Fine fibrinous filaments were observed in the serous spaces in fourteen preparations, disappearing as the clot contracted, and the corpuscles became closely aggregated to one another. A "zone immobile" of spectral bacteria was present in four cases, and bacteria and fungi made their appearance after intervals of some days in four others.

Method adopted in describing this condition.

In place of repeating the general statements contained in the previous report regarding the phenomena observed in specimens of choleraic blood in general, it may be well here to introduce a detailed account of those occurring in an individual characteristic case in which observations were carried on for some time.

Cholera blood—a typical case.

Three specimens of blood were obtained three hours before death from a patient, pulseless, in profound collapse, and with a rectal temperature of 105° F. The blood was very dark-coloured and appeared abnormally thick. Of the three specimens, one (*a*) consisted of an ordinary preparation destined for immediate examination, whilst the other two (*b* and *c*) were mounted in wax cells for continued observation. The first specimen (*a*) was examined at once. The red corpuscles were aggregated in irregular masses, appeared very diffluent, and showed very little tendency to form

* This phenomenon has been observed by MM. Coze and Felz in the blood in septcæmia, typhoid, variola, and measles (op. cit. pp. 76, 148, 196, 242), and by Davaine in that in charbon (Comptes Rendus, T. LVII, p. 351, August 10th, 1863).

rouleaux. Leucocytes were present in extreme abundance and in a state of great activity. In some of the serous spaces an appearance of a meshwork of very delicate threads was visible, due to the presence of filaments of a fibrinous nature in some cases; to fine processes connected with active leucocytes in others; and, to fallacious appearances due to the presence of very tenuous, ill-defined leucocytes, the contained molecules of which, coming out more distinctly into view than the investing protoplasm, appeared as though free in the surrounding fluid. Not a trace of bacteria or of vibriones could be made out.

Preparations of the same blood in wax cells.

The two other preparations were not examined for twenty-two hours. At the close of that period both presented similar features, so that one description is sufficient for them. The serum was abundant and quite clear, forming a wide zone around the small clot occupying the centre of the preparation. The red corpuscles were well preserved and were irregularly massed together. White corpuscles were present in extreme abundance, their numbers being so great as to cause the formation of a white fringe along the edge of the clot visible to the naked eye, whilst under the microscope very many fields were entirely occupied by masses of them. Very few of the corpuscles now retained any movement or showed any changes in form, and the majority were circular, finely molecular, and contained a variable number of refringent granules. Twenty-four hours later—forty-six from the date at which they were obtained—but little change had occurred in either specimen. The white corpuscles had become more or less distinctly vacuolated and all movement had ceased; the red corpuscles were well preserved and the serum was abundant, quite clear and free of any traces of bacteria or vibriones. The preparations were examined at intervals. Five days after the last examination the changes in the leucocytes had advanced considerably, increased vacuolation being visible in some, whilst in others the granular mass of the bioplast protruded more or less from one or other side of a large clear vacuole; in some the two bodies were almost entirely separate, whilst in others total separation had been completed and the granular mass exhibited various stages of disintegration—a process which resulted in the appearance of free

granules and molecules and small patches of such particles throughout the serum.

Result of prolonged examination of the specimens.

After this, although the preparations were retained under observation for a month longer, the only further changes observed in them were increasing disintegration of the white corpuscles, loss of distinctness in the outlines of the red corpuscles, and a change of their colour to a bright rosy hue, accompanied by a certain amount of staining of the serum. The preparation remained fluid throughout the entire period of observation, but no development of any unequivocal bacteria or vibriones ever occurred. There was of course ultimately a generally-diffused sprinkling of granules and molecules derived from the breaking-up of the leucocytes, but neither by form, growth, nor motion did they show themselves to be truly bacterial in their nature.

The foregoing examples present the leading features of cholera blood.

This case presented almost all the characteristic features of choleraic blood, the only one which was not observed being the swarming movement of the contents of the white corpuscles; but as the preparations, after the first day or two, were only examined at intervals, the phenomenon was very probably present, although the precise time of its occurrence did not coincide with that at which any examination took place.

No characteristic organisms visible in the blood in cholera.

As in all our previous examinations not the faintest trace of evidence presented itself in favour of the presence of any bacteria or other foreign organisms or germs in the blood in cholera—all the phenomena observed were ascribable to alterations, relative or absolute, in the normal elements of the blood, not to the presence of any new or extraneous bodies of such a nature as to be detected by microscopical research.

We have now examined numerous specimens of blood derived from cases of every degree of severity and at every stage of the disease during life and shortly after death, and, had the presence of foreign organisms in the blood been

essentially related to the disease in one way or other, whether as causes of the diseased condition or as indications of its existence, it is scarcely conceivable that they should have consistently failed to afford the slightest evidence of their presence. We are well aware that these statements are likely to be received with some incredulity by a very large number of the members of the medical profession, made as they are at a time when views regarding the important and almost necessary influence of "germs," "bacteria," "microzymes," &c., in the development of epidemic disease are so widely diffused and so much quoted; but, in bringing our examinations of the blood from this point of view to a close, we feel bound to state our results and conclusions distinctly.

C.—Microscopic examinations of the Blood in Diseases other than Cholera.

The blood in Vaccinia.

In considering questions connected with the blood in cholera, more especially in reference to the doctrines referred to at the close of the previous section, it was important to determine whether the blood in diseased conditions beyond all doubt capable of direct communication by inoculation, differed from that in cholera in any important respect, more especially whether it necessarily contained distinct organisms of any kind recognisable by the use of the microscope. After some deliberation vaccinia was selected as the most convenient for this purpose, as there is no objection to the production of the condition in the human subject and a definite series of observations at known periods from the introduction of the morbid agent into the system can be carried out.*

The table on the next page shows the results of the examination of forty-seven specimens of blood derived from five cases in which vaccination had been performed:—

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* There is another advantage attending the selection of vaccinia; the disease whilst running a definite course is not of a fatal or dangerous nature, and therefore phenomena due to impending death of the organism, or of any of its parts, are not likely to occur, *vide infra*, p. 32.

TABLE III.

Microscopic characters of Vaccinial Blood.

Case.	No.	Serum.	Red corpuscles.	White corpuscles.	Molecular matter.	Bacteria.	Fungi.	Remarks.
I	1	Clear.	Some echinulated.	Very few.	None.	None.	None.	24 hours after vaccination.
"	2	"	Normal.	Normal.	"	"	"	" " " "
"	3	"	"	"	"	"	"	" " " "
"	4	"	"	"	Sprinkling, motile.	"	"	32 " " " Abundant fibrinous threads.
"	5	"	"	"	Very few particles.	"	"	48 " " "
"	6	"	"	"	Abundant.	"	"	56 " " "
"	7	"	Some echinulated.	"	"	"	"	56 " " "
"	8	"	Normal.	"	None.	"	"	72 " " "
"	9	"	Some echinulated.	"	"	"	"	104 " " " Some bioplastic fragments.
"	10	"	Normal.	"	"	"	"	144 " " "
"	11	"	"	"	"	"	"	9 days " " " " "
"	12	"	"	"	One or two particles.	"	"	9 days 6 hours "
II	1	"	"	"	Sprinkling.	"	"	24 hours after "
"	2	"	"	"	Abundant.	"	After 72 hours.	24 " " "
"	3	"	"	"	None.	"	None.	2 " " "
"	4	"	"	"	"	"	"	32 " " " Bioplasts distended and crowded with moving particles.
"	5	"	Many broken up.	"	Abundant.	"	"	48 " " "
"	6	"	Normal.	"	"	"	"	48 " " "
"	7	"	"	"	None.	"	"	72 " " "
"	8	"	"	"	"	"	"	96 " " "
"	9	"	"	"	"	"	"	104 " " "
"	10	"	"	"	Sprinkling.	"	"	128 " " "
"	11	"	"	"	"	"	"	9 days " "
III	1	"	"	Abundant.	Abundant.	"	"	72 hours " "
"	2	"	"	"	"	"	After 7 days.	72 " " "
"	3	"	"	"	A sprinkling.	"	"	72 " " "
"	4	"	"	"	"	"	"	72 " " "
IV	1	"	Somewhat diffluent.	Normal.	None.	"	"	8 days " "
"	2	"	Echinulated.	"	"	"	"	8 " " " A very thin layer.
"	3	"	Normal.	"	"	"	"	8 " " "
V	1	"	"	"	Sprinkling.	"	"	48 hours " "
"	2	"	"	"	"	"	"	48 " " "
"	3	"	"	"	None.	"	"	120 " " "
"	4	"	"	"	"	"	"	120 " " "
"	5	"	"	"	"	"	"	144 " " "
"	6	"	"	"	"	"	"	158 " " " Abundant fibrinous threads.
"	7	"	"	"	"	"	"	158 " " " Bioplasts very active.
V	37	37	.....	...	17	...	2	

Leucocytes not numerous in the blood in vaccinia.

The specimens, as shown in the table, dated from twenty-four hours up to nine days subsequent to vaccination. Of the five cases, No. I was abortive, no vesicles ever making their appearance. Nos. II and III were moderately successful, whilst No. IV, and No. V, which was vaccinated directly from it, were excellent cases with large well-developed vesicles. The most prominent respect in which these specimens of blood differed from those in cholera was in the absence of

any appreciable leucocytosis; the only specimens in which the white corpuscles were in excess belonging to case II, the subject of which was in an anæmic condition, due to influences of climate, and habitually showed an abundance of leucocytes in the blood.

Motile particles in the blood in vaccinia.

In seventeen of the forty-seven specimens motile particles were observed. These were of extreme minuteness, appearing as barely perceptible points, with a rotating or jerking movement in the inter-corpuscular spaces. They showed no evidences of being organisms. Their movements were not more active than those in other instances, certainly due to mechanical action. These particles were as abundant in the abortive case as in any of the others, and were least abundant in the two successful ones, none being present in the specimens from one and very few in those from the other of these; and, as they have been already mentioned as occurring in specimens of blood obtained from healthy individuals, they do not appear to demand further consideration here.

Absence of bacteria in the blood in vaccinia.

Distinct bacteria were absent throughout the whole series, and although fungi occurred in three instances, they were not developed until after uncertain intervals, did not belong to the same species in the several instances, and were not confined to the same case, so that their extraneous origin was evident.

The blood in syphilis.

Specimens of blood from cases of syphilis were next examined, but in these also no foreign organisms could be detected. It was thus manifest that as the blood in these two undoubtedly inoculable diseases (into which a multiplication of the poison within the system takes place) showed no evidence of the presence of organised ferments,* it is

* "The proof that virus which has no organisation may be contagious in infinitesimal quantities, may be found in the transmission of syphilitic virus. Try to calculate the relation between the proportion of virus which has communicated syphilis to a man, and the proportion of virus from the mucous surface of the throat of the same individual which proves sufficient to transmit the disease to another person. Or estimate the quantity of virus contained in the spermatozooid of a syphilitic individual, a quantity sufficient to produce the disease in the mother and to infect the ovum fecundated by the spermatozooid. In all such cases, if we cannot exactly conceive how an albuminoid substance transmits its alteration to another organism, this is not a reason for admitting special phenomena in these cases, and an infection by multiplication of microscopic beings."—(M. Onimus.) A *resumé* of a critical analysis of views on septicæmia in the *Moniteur Scientifique-Quesneville* (October) by A. B. MacDowall:—London Medical Record, November 1873, p. 722.

not to be wondered at that we have found it impossible to say from microscopic examination of the blood whether cholera should be classed with those few diseases which are known to be inoculable or with those which are not.

Under what circumstances are organisms to be found in the blood?

Having failed to detect the presence of bacteria or their germs as an essential feature in the blood of an epidemic disease (cholera) and of two undoubtedly contagious and inoculable ones (vaccinia and syphilis), the next question that suggested itself was, under what circumstances are such bodies to be found in the blood; careful examinations were, accordingly, made of the blood in the course of numerous and varied experiments on animals, and the following were the results.

Tabular Statements IV–X.

The experiments in question have been arranged in separate tables, according to the nature of the procedure employed in the various instances; and a final table is given showing the cases in which bacteria were present in the blood, the nature of the experiment, and any points of interest which the cases presented.

TABLE IV.

Microscopical characters of the blood in cases in which Choleraic materials were injected into Veins.

Case.	Specimen.	Character of fluid injected.	Bacteria in blood at varying periods after operation.
I	1	Fresh choleraic evacuation	None.
	2	" " "	"
	3	" " "	"
II	4	" " "	"
	5	" " "	"
III	6	" " "	"
	7	" " "	"
IV	8	" " "	"
V	9	Fresh boiled choleraic evacuation	"
VI	10	Fresh strained choleraic evacuation ...	"
VII	11	Fresh boiled and strained choleraic evacuation...	"
VIII	12	" " " " " " ...	"
	13	" " " " " " ...	"
IX	14	Fresh strained choleraic evacuation ...	"
X	15	Fresh boiled and strained choleraic evacuation...	"
XI	16	Fresh strained choleraic evacuation ...	"
XII	17	Fresh boiled and strained choleraic evacuation...	"
XII	17		... ...

TABLE V.

Microscopic characters of the blood in cases in which Non-Choleraic Organic fluids were injected into Veins.

Case.	Specimen.	Nature of fluid injected.	Bacteria in blood at varying periods after operation.
I	1	Peritonitic fluid	None.
	2	,, ,, ...	,,
II	3	Blood	,,
	4	,, ...	,,
III	5	Solution of healthy fæces	A sprinkling of active bacteria.
IV	6	Strained solution of healthy fæces ...	None.
	7	,, ,, ,, ,, ...	,,
V	8	Boiled and strained solution of healthy fæces ...	,,
	9	,, ,, ,, ,, ,, ,, ...	,,
VI	10	Strained solution of healthy fæces ...	,,
VII	11	Boiled and strained solution of healthy fæces ...	,,
VII	11		Bacteria present in one.

TABLE VI.

Microscopic characters of the blood in cases in which Peritonitic fluid was injected into the Peritoneal cavity.

Case.	Specimen.	Nature of fluid injected.	Bacteria in blood at varying periods after operation.
I	1	Peritonitic fluid	None.
,,	2	,, ,, ...	,,
II	3	,, ,, ...	Three bacteria observed.
,,	4	,, ,, ...	None.
III	5	,, ,, ...	,,
IV	6	,, ,, ...	,, *
V	7	,, ,, ...	,,
,,	8	,, ,, ...	,,
VI	9	,, ,, ...	,,
VII	10	,, ,, ...	,,
,,	11	,, ,, ...	,,
VII	11		One.

* Some bodies appeared in this, which were at first taken for large bacteria, but which turned out to be crystals.

TABLE VII.

Microscopic characters of the blood in cases in which Organic matters were injected into the Peritoneal cavity.

Case.	Specimen.	Nature of fluid injected.	Bacteria in blood at varying periods after operation.
I	1	Urine and tinctura iodi	None.
„	2	„ „	One or two bacteria observed.
II	3	Solution of healthy fæces	None.
„	4	„ „ „	„
III	5	„ „ „	„
„	6	„ „ „	„
IV	7	„ „ „	„
IV	7		One.

TABLE VIII.

Microscopic characters of the blood in cases in which purely Chemical irritants were injected into the Peritoneal cavity.

Case.	Specimen.	Nature of fluid injected.	Bacteria in blood at varying periods after operation.
I	1	Tinctura iodi and water	One or two.*
„	2	„ „ „	None.
II	3	Liquor ammoniæ	Abundant, active.
III	4	Tinctura ferri perchloridi	None.
„	5	„ „ „	„
IV	6	„ „ „	„
V	7	„ „ „ and water ...	„
„	8	„ „ „ „ ...	„
VI	9	„ „ „	„
„	10	„ „ „	„
VI	10		Two

* This specimen was obtained from a small vein, rendering chances of accidental contamination greater than usual.

TABLE IX.

Microscopic characters of the blood in cases in which HEALTHY *animals were killed* WITHOUT *previous experiment.*

Case.	Specimen.	Temperature (Fahr.).	Kind of death.	Bacteria in the blood at death, and up to 48 hours subsequently.
I	1	73° 9'	Killed under chloroform; examined at once.	None.
„	2	„	Ditto ditto	„
„	3	„	Ditto ditto	„
II	4	71° 9'	Ditto ditto	„
III	5	85° 5'	Ditto ditto 8 hours afterwards	Abundant, active.
IV	6	86° 3'	Ditto ditto 8 „ ...	„ „ still. (blood from veins).
„	7	„	Ditto ditto 8 „ ...	None (blood from left side of heart).
V	8	69° 6'	Ditto ditto 12 „ ...	A sprinkling of bacteria.
VI	9	73° 1'	Ditto ditto 24 „ ...	None.
VII	10	72° 8'	Ditto ditto 24 „ ...	Abundant.
„	11	„	Ditto ditto 24 „ ...	„
VIII	12	68° 0'	Ditto ditto 24 „ ...	A sprinkling.
„	13	„	Ditto ditto 24 „ ...	Very abundant.
IX	14	67° 6'	Ditto ditto 24 „ ...	A few.
„	15	„	Ditto ditto 24 „ ...	None.
X	16	69° 4' 69° 1	Ditto ditto 48 „ ..	Abundant.
XI	17	67° 3' 63° 9'	Ditto ditto 48 „ ...	None.
XI	17			Nine.

TABLE X.

A Summary of all the cases in which Bacteria were present in the blood.

Case.	Specimen.	Nature of case.	Bacteria in blood at varying periods after death.
I	1	Injection of healthy feculence into the veins.	A sprinkling of bacteria; 5½ hours after death.
II	2	Injection of peritonitic fluid into the peritoneal cavity.	Three bacteria observed immediately after death.
III	3	Injection of urine and tinctura iodi into the peritoneal cavity.	One or two bacteria observed immediately after death.
IV	4	Injection of liquor ammoniæ into the peritoneal cavity.	Abundant bacteria observed immediately after death.
V	5	Injection of tinctura iodi and water into the peritoneal cavity.	One or two bacteria observed immediately after death.
VI	6	Healthy dog killed by chloroform ...	Abundant after 8 hours.
VII	7	„ „ ...	„ „ „ „
VIII	8	„ „ ...	A sprinkling „ 12 „
IX	9	„ „ ...	Abundant „ 24 „
„	10	„ „ ...	„ „ „ „
X	11	„ „ ...	A sprinkling „ „ „
„	12	„ „ ...	Very abundant „ „ „
XI	13	„ „ ...	A few „ „ „
XII	14	„ „ ...	Abundant „ 48 „

Analysis of Tables IV–X: Bacteria and Post-mortem changes.

The above tables show that of seventy-three specimens of blood derived from forty-seven different animals, fourteen, or somewhat over 19 per cent., contained bacteria in smaller or larger numbers; that the presence of bacteria was not the result of any special experimental treatment; and that bacteria may be found in specimens of blood obtained from the bodies of animals killed while in full health, and without having been subject to any operative interference previously. The animals were in every instance dogs, so that the question of idiosyncracy in hindering or promoting the development of bacteria, can be so far set aside when the results of any one set of cases are compared with those of the others.* Of the fourteen specimens ten were obtained from the bodies of animals at periods varying from 5½ to 48 hours after death, and only four from cases in which the animals had been killed immediately before the examination, and in which changes dependent on *post-mortem* decomposition could not be supposed to have played any important part in the production of peculiarities in the blood. Table X shows the length of time which elapsed in each instance between the death of the animals and the time at which the specimens of blood were obtained, and brings out the fact very distinctly that, in so far as the whole of the present experiments are concerned, it was this that almost invariably determined the existence of bacteria in the blood. In three of the four instances in which bacteria were found in the blood immediately after the death of the animal the numbers present were so very small as to fail to constitute a characteristic of the blood or escape the suspicion of accidental introduction.

Temperature and the development of bacteria.

In one specimen (No. 3, Table VIII), however, obtained immediately after death, bacteria were present in abundance; and in another (No. 5, Table V), in which their numbers were considerable, death had occurred at such a short time previously (5½ hours) that it may not be deemed warrantable to conclude that all the bodies present had really been developed subsequent to the death of the animal. That it would really be an unwarrantable conclusion is, however, very doubtful, as two of the experiments in healthy dogs

* In the blood of rabbits, for example, bacteria are said to be much more readily developed than in the blood of other animals.

show that, with the high temperature of the hot months, a development of bacteria may take place within a very few hours in the blood of animals into the system of which on such bodies had been previously artificially introduced. In the case under discussion the body was exposed to the hottest part of the twenty-four hours of a day towards the close of May. Even, however, if it be assumed, that the bacteria were certainly in this case not due to *post-mortem* processes, their appearance in the blood can be readily explained without supposing that they exerted any essential influence on the death of the animal, for, as death followed within three hours after the injection of several drachms of fluid containing an abundance of bacteria, it may well have happened that all those introduced had not been destroyed ere death occurred, and that, on its occurrence, the medium and temperature being favourable, they rapidly developed and multiplied.

Organisms developed in the tissues of HEALTHY animals shortly after death.

In the experiments in which healthy animals were employed, the procedure consisted in administering chloroform until death ensued, and then laying the bodies aside on a shelf without further interference. The results do not manifest that freedom of the healthy tissues and fluids from the elements of bacteria which is maintained by some of our most distinguished observers. That such a freedom should exist is certainly not supported by the analogy of processes which may be observed in healthy vegetable cells, and there is much reason to suspect that the observations on which the doctrine has been founded have been too limited and too little varied to allow of valid generalisations being drawn from them. This especially would appear to be the case in regard to conditions of temperature, for it is manifestly impossible to lay down a general law in regard to such developments, from observations carried on under one set of conditions only. In order that future experiments on this point may be compared with those now given, a column has been added to Table IX, showing the mean temperatures of the days on which these experiments were conducted.

Organisms in the blood of DYING animals.

Only one case remains demanding any special notice, namely, that of Specimen No. 3 Table VIII, in which active bacteria were present in abundance in the blood immediately after death. The animal from which the speci-

men was obtained was in a state of extreme depression, and evidently dying when chloroform was administered to it, and the chief point of interest lies in the fact that the morbid condition had in this instance not been induced by the introduction of any organic fluid, or of any fluid which might be supposed to contain bacteria or their germs, but was due to the intense and destructive inflammation resulting from the injection of liquor ammoniæ into the peritoneal cavity.

This case is a parallel of those described by Dr. Burdon Sanderson in his researches into infective inflammation, in which inflammatory fluids of a highly infective nature,—a nature which is, according to that experimentor, characterized by the presence of bacteria in the effused fluids,—resulted from the introduction of pure chemical media destructive of bacterial organisms, or which had been previously subjected to boiling;—cases in which, whatever part the organisms in the fluid play in regard to its infectious nature, there could be no doubt as to the manufacture of that fluid with all its infectious properties within the living organism by a process of self-infection.

Post-mortem development of organisms in the glands and various tissues of the body.

In the former report on experiments on animals, the occurrence of peculiar elongated vibriones in the mesenteric glands, in cases in which death had resulted on injection of choleraic fluids into the circulation, was recorded, and our attention was again attracted to the subject by observing similar organisms in several of the specimens of blood obtained from healthy animals at intervals after death. Renewed examinations of the gland fluid and of the mucous membrane of the small intestines under similar circumstances were accordingly undertaken.

The table given on next page shows the results of the examinations of the contents of the mesenteric glands:—

TABLE XI.

Examinations of fluid from Mesenteric Glands at varying periods after death.

Case.	No.	Nature of Case.	Period of examination after death.	Bacteria and other Organisms.
I	1	Healthy dog	Immediate	None.
II	2	Ditto	Ditto	Ditto.
III	3	Ditto	24 hours	Abundant.
IV	4	Dog; abdomen opened and splanchnic nerves irritated 24 hours before	Immediate	None.
V	5	Healthy dog	Ditto	Ditto.
	6	Ditto; portion of gland having been ligatured and excised	72 hours	A few.
	7	Ditto; portion of gland having been ligatured, excised, and immersed in melted wax...	72 „	Ditto.
VI	8	Healthy dog	24 „	Abundant.
VII	9	Ditto	16 „	Ditto.
VIII	10	Ditto	48 „	Ditto.
IX	11	Ditto	24 „	Very few.
X	12	Ditto	24 „	None.
XI	13	Ditto	48 „	Abundant.
XII	14	Ditto	Immediate	None.
XIII	15	Man who died of cholera ...	6½ hours	Ditto.
XIV	16	Healthy dog	Immediate	Ditto.
	17	Ditto; gland fluid preserved in wax-cell	24 hours	Ditto.
XV	18	Dog; killed 4 days after injection of choleraic fluid into veins ...	Immediate	Ditto.
XVI	19	Dog; died after injection of choleraic fluid into veins	1 hour	Ditto.
XVII	20	Dog; died 3 hours after injection of healthy alvine discharge into veins	5½ hours	A few.
XVIII	21	Healthy dog	8 „	Abundant.
XIX	22	Ditto	8 „	A sprinkling.
XX	23	Dog; died 8 hours after injection of choleraic fluid into veins ...	1½ „	None.
XXI	24	Man; died of cholera	5 „	Ditto.
XXII	25	Dog; killed 48 hours after injection of choleraic matter into veins ...	Immediate	Ditto.
XXIII	26	Dog; killed 48 hours after injection of boiled choleraic matter into veins	Ditto	Ditto.
XXIV	27	Dog; killed 24 hours after injection of healthy alvine discharges ...	Ditto	Ditto.
XXV	28	Dog; died after injection of boiled healthy alvine discharges ...	Some hours	Ditto.
XXVI	29	Dog; killed 24 hours after injection of choleraic fluid	Immediate	Ditto.
XXVII	30	Ditto 48 ditto ditto...	Ditto	Ditto.
XXVIII	31	Ditto 48 ditto ditto...	Ditto	Ditto.
XXIX	32	Ditto 24 ditto ditto of healthy alvine dicharges ...	Ditto	Ditto.
XXX	33	Ditto 24 ditto ditto...	Ditto	Ditto.

TABLE XI,—*continued.*

Examinations of fluid from Mesenteric Glands at varying periods after death—continued.

Case.	No.	Nature of Case.	Period of examination after death.	Bacteria and other organisms.
XXXI	34	Dog; died 12 hours after injection of fresh choleraic fluid ...	12 hours	A sprinkling.
XXXII	35	Dog; died after injection of peritonitic fluid into peritoneal cavity ...	Some hours	Abundant.
XXXIII	36	Dog; died after injection of peritonitic fluid into peritoneal cavity ...	A few hours	A few.
XXXIV	37	Ditto ditto ...	10 hours	Abundant.
XXXV	38	Ditto ditto ...	12 „	Ditto.
XXXVI	39	Ditto ditto ...	Some hours	Ditto.
XXXVII	40	Dog; killed 24 hours after injection of peritonitic fluid into peritoneal cavity	Immediate	None.
	40			Present in 17 cases.

This table hardly requires comment, as the results speak for themselves.

Organisms in the glands.

In seventeen of the forty specimens bacteria were present in the contents of the glands, but these were *derived from healthy dogs* in no less than ten instances; and the *only* feature common to all the cases in which bacteria and allied organisms were present, was that a certain interval of shorter or longer duration had elapsed between death and the examination of the glands.

The results afforded by an examination of the mucous membrane of the intestinal tract were naturally not so uniform and well defined as those regarding the contents of the glands. That membrane is exposed to portions of undigested and disintegrating materials which are constantly more or less liable to contain bacterial elements and to contaminate with these any specimens obtained from the surface with which they are in contact. Nevertheless, even here important indications of the rapidity with which *post-mortem* changes may give rise to remarkable phenomena were not wanting on investigation. Although on immediate examination of the mucous membrane few bacteria and none of the large serpentine vibriones (previously described as occurring in preparations of the blood and the contents of the glands) were to be found, yet, when a period

had elapsed between the death of the animal and the examination of the body, the extent to which such organisms had developed and invaded the tissues was most remarkable. This condition, as in the previous cases, occurred without reference to the cause of death—no matter, whether the animal had died owing to the introduction of organic fluids into the system or had been killed whilst in perfect health.

The two following cases are selected as examples of the phenomena present in such cases, and of the coincidence of the occurrence of a development of vibriones in the mucous membrane of the small intestines, in the interior of the mesenteric glands, and, in one of the cases, in the blood:—

Vibriones in the tissues of a healthy dog 24 hours after death.

Case I.—A powerful, healthy pariah dog was killed by means of chloroform at 8 A. M. of December 1st, 1873, and the body laid aside for twenty-four hours. At the close of that period a *post-mortem* examination was performed, and the temperature having been comparatively low (73°·1 F.) decomposition was not at all advanced in so far as the unaided senses could determine. Microscopic preparations were obtained from various viscera, and were immediately examined with the following results:—

1. *Reddish fluid from the sac of the pericardium.*—No red blood corpuscles could be found in this, but numerous, elongated, motionless, vibrionic filaments were present, in some cases showing one or more distinct joints.

2. *Blood from the heart.*—This was firmly coagulated. It contained an abundance of large crystals, and the red corpuscles were in great part disintegrated, but no *distinct* bacteria or vibriones were to be found in it.

3. *Fluid from the interior of the mesenteric glands.*—The cut surface of the gland was of a dull, dirty pinkish hue. The fluid was full of molecular *débris* and oily granules. It contained, in addition, numerous staves, thick, jointed, and in some instances exhibiting characteristic active movements.

4. *A scraping from the clean surface of the mucous membrane of the small intestine.*—This was almost entirely composed of a mass of bacteroid staves of all sizes; some undivided, others segmented, and all motionless.

Vibriones in the blood, glands, &c, of a healthy dog 48 hours after death.

CASE II.—A healthy dog was killed, as in the former case, and set aside for forty-eight hours, from the morning of the 20th to that of the 22nd of December 1873. Specimens of blood from the heart, of fluid from the mesenteric glands, and of the surface of the mucous membrane of the small intestines, were then procured and examined with the following results:—

1. *Blood.*—The red corpuscles were well preserved. The white corpuscles were distended into hyaline spheres, with their contained granules aggregated into one or more distinct masses. Throughout the serum there were numeous free particles in active mechanical movement, and a sprinkling of large, elongated, bacteria and vibriones divided into two or more segments, and in some cases showing characteristic movements.

2. *Fluid from the interior of the mesenteric glands.*—This was crowded with molecular matter and oily granules, and contained an abundance of long, active vibriones, swimming to and fro with an undulating flexion, dependent on bending both at their component joints and in the course of the individual segments.

4. *Mucous membrane of the small intestines.*—Scrapings from this were full of flakes formed of epithelium, stained yellow by the colouring matter of the bile. Between these flakes there was a thick felted mass composed of large bacteria, and of elongated, jointed vibrionic bodies like those in the contents of the glands, and showing the same undulating movement as the latter, whenever they had room and freedom to do so.

In other cases, a similar development of vibriones was found to have occurred beneath layers of exudation or in the deeper strata of the epithelial coat of the intestine, and the appearances were such as might readily have been supposed to indicate the existence of severe lesions dependent on parasitic invasion of the tissues by vegetable organisms, had they not been found to occur in healthy subjects as well, and to be dependent on *post-mortem* changes and developments.

'Mycosis intestinalis.'

Even those who believe in the general freedom of the healthy tissues and fluids from the elements of vegetable organisms, allow that the intestinal mucous membrane does not participate in this freedom, and it would hardly have been necessary to

enter upon the question of the phenomena dependent on the rapid *post-mortem* development of such organisms there, had it not been for the prominence that has been given to phenomena, which are, at all events, very similar to these, occurring in the so-called 'mycosis intestinalis.'* That such developments take place *post-mortem* in some cases, is, of course, no evidence that they always do so, or that they cannot occur during life and give rise to injurious or fatal results; but the fact is one which requires to be prominently brought forward, and to be carefully borne in mind in the investigation of all such obscure etiological subjects.

The pathological significance of vegetable organisms in the tissues after death.

In our former report we drew special attention to these phenomena and gave a minute description with figures of the objects referred to; but as we have since, on more than one occasion, observed statements to the effect that organisms (beyond any reasonable doubt identical in

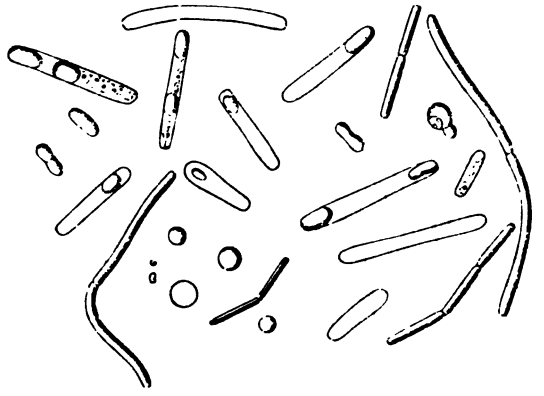

Fig. 1. × 1500.
Organisms found in the tissues of *healthy* animals a few hours after death.

their nature with these) had been detected after death in this or in that disease, and conclusions drawn as to the significance of their presence which are more conducive to the retardation than to the advance of our knowledge of the true pathology of these diseases, we again give a wood-cut

* In regard to this, see "The London Medical Record, 1874," containing an abstract from the "Berliner Klinische Wochenschrift," of Fränkel and Orth on two cases of Malignant Pustule in the adult. The points of chief interest, from the present point of view, regarding these cases, are: (1*st*), that in one case the *post-mortem* examination did not take place until the second day after death; and (2*nd*), that the blood of the second case examined a few hours before death, and when the patient was collapsed and cyanotic, afforded only negative results, although examined under high powers and with immersion lenses; while on *post-mortem* examination an abundance of bacteria were discovered in it.

of the principal forms presented by these *post-mortem* developments, as seen under a $\frac{1}{16}$ of an inch immersion objective.

The genera to which these organisms belong.

It is difficult to give these bodies one name which shall embrace all the forms. Some are long and jointed, extending in a few cases almost across the field of the microscope, reminding us of the *Bacillus subtilis* figured in Cohn's "Memoir on Bacteria;" * others are more like *Vibrio rugula* and *Vibrio serpens:* whilst intermixed are innumerable bacteria of various forms and sizes; some with vacuoles at one end, others showing them at both ends or towards the middle, with here and there circular cells containing oily molecules not unlike Cohn's *Saccharomyces glutinis* in appearance. After being kept for a day or two, the activity of the vibriones, &c., diminishes or ceases altogether, and eventually the staves break up into oil-like beads held together by a soft, hyaline material.

The Bacteridia in 'Malignant pustule.'

We have frequently found these in the blood and in all the organs of the body of healthy animals within twelve hours after death, and considerably sooner when the temperature was unusually high. On the last occasion when we undertook the examination of a healthy dog specially with the object of elucidating this matter, we found that the spleen was particularly affected; there was a regular net-work of *Bacillus* or *Vibrio*-like rods throughout the substance of the organ. This appearance very naturally suggested to us that the presence of "Bacteridia" in 'malignant pustule' and 'the blood,' so frequently brought forward in support of the theory of the causation of disease by vegetable organisms, may after all be more a consequence than a cause; a suggestion which receives support from the fact that Cohn refers these particular "Bacteridia" to the genus *Bacillus*.

'Microzymes.'

In all our experiments and statements we have rigidly confined the use of the terms bacteria and vibriones to bodies which, either by form, motion, or development, have distinctly shown that they really were true bacteria of one form or other, and have refrained from classing minute particles, granules, and molecules of undetermined nature along with them. Many

* *Vide* Quarterly Journal of Microscopical Science, Vol. XIII, new Series, 1873, page 156.

authors use the word 'microzymes' to include a heterogeneous mass of minute bodies, organic and inorganic, living and dead;* in fact, any molecular or granular particles to be found in fresh or decomposing fluids or tissues; and many statements and theories regarding the production of disease are founded on such arbitrary classification and vague nomenclature—

> "human pride
> Is skilful to invent most serious names
> To hide its ignorance."

Moreover, the terms microzymes and bacteria are very commonly employed, as though they were equivalent; whereas the one is a name invented to suit certain theoretical views, whilst the other is a definite term employed in classification to include certain low vegetable organisms; hence it is evident that if all minute particles of matter, even if only of organic and living matter, are to be called microzymes, and that term then used and understood as equivalent to bacteria, great confusion must be induced.† Dr. Beale has pointed this out very clearly when arguing in favour of his views regarding the nature of "disease germs," but the confusion still prevails, and owing to its existence and to the vague use of terms, it is very difficult to estimate the value of many of the statements at present adduced as evidence of the existence of bacteria in morbid fluids and tissues.

The relation of bacteria to disease.

There appears to be a tendency to assume on very insufficient grounds that such organisms are necessarily the causes of all diseases of an epidemic or communicable character, and, consequently, to recognise as vegetable parasites all minute particles of an undetermined nature occurring in the fluids and tissues in such diseases; but, as Dr. Bastian has ably pointed out, that such an etiology must necessarily be found for these diseases, or has been distinctly demonstrated for any of them is by no means the case.‡ This comes out very clearly when, even in regard to septicæmia, a disease for which a vegetable origin has been accepted

* According to Béchamp, all the "granulations moléculaires" visible in animal and vegetable tissues are "microzymas," or germs capable of evolving bacteria. Such bodies are, according to him, constantly present in the blood of animals, the fibrine being merely a false membrane formed of microzymas, the life of which is not destroyed by an exposure to the influence of boiling with water, as is proved, in his opinion, by their subsequent development into bacteria, and action as ferments when submitted to suitable conditions.—Comptes Rendus, Tomes LX, LXVIII, LXIX.

† On this point *vide* Dr. Burdon-Sanderson's remarks at the British Association, 1873.

‡ Appendix E, "The Beginnings of Life."

more generally, perhaps, than for any other, we find that an authority like Dr. Burdon-Sanderson refuses to allow that anything beyond a coincidence has been proved to exist between the occurrence of bacteria and the presence of infective properties in inflammatory fluids,* and that observers, such as Robin,† Stricker,‡ and Billroth,§ fail to detect such bodies in the blood of *living* animals suffering from the disease.

The significance of the presence of organisms in the tissues after death.

Our own experience has not been favourable to the acceptance of any such doctrines regarding the influence of bacteria and allied organisms, nor can we accept them until much more evidence than at present exists has been adduced in their favour. We feel that all evidence founded on *post-mortem* examinations, however remarkable the phenomena in such cases may be, requires most cautious scrutiny; for, even if it be granted that the normal tissues and fluids do not, as a rule, contain the elements of bacteria and remain free of such organisms for prolonged periods under peculiar circumstances, these circumstances, as our experiments show, are certainly not those to which dead bodies are ordinarily exposed.

In regard to this particular point, questions relative to the ultimate origin of the bacteria are not of special moment. It matters little whether their presence be due to entrance from without, to the development of inherent germs, or to heterogenetic transformations in the elements of the fluids and tissues; the really important fact being that, in one way or other, they are capable of appearing in healthy as well as in morbid materials. Even were vegetable organisms of a distinct nature demonstrated to exist in the dead fluids and tissues of each disease, the fact might merely indicate the existence of peculiarities in the composition of the medium, and additional evidence in favour of their causative relations to the antecedent disease processes would yet be necessary.

The significance of their presence during life.

Where the presence of such organisms is demonstrated during the life of the host, the case is no doubt different; but even here, there is a great lack of evidence to prove that they really are causes and not consequences of the diseased condition. Dr. Burdon-Sanderson's experiments

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* *The Lancet*, Vol. I, 1873, p. 734.
† "*Traité Du Microscope*," Paris, 1871, p. 932.
‡ The *Medical Times and Gazette*, Vol. I, 1873, p. 62.
§ The *Medical Times and Gazette*, Vol. II, 1874, p. 48.

prove the development of infective inflammatory products as the result of the introduction of pure chemical irritants, and we ourselves have found bacteria in the blood of an animal dying from such an experiment, and yet it cannot be maintained that the bacteria present in such cases were the causes of the diseased condition.

The evidence that they are of no significance.

Moreover, other evidence is in existence directly opposed to the necessary agency of vegetable organisms or, more correctly, of living matter of any kind, as the effective agent in the production of diseases of this nature; for Stricker* and Panum† find that boiling does not affect the virus of septicæmia, whilst Davaine states that neither boiling nor rapid desiccation affect that of *Charbon.*‡ Our own observations on this particular point will be found narrated further on (pages 46, 49, 56).

Leucocytosis incompatible with the co-existence of bacteria.

There is one point in regard to this question which appears to be worthy of more attention than it has as yet generally met with, and this is, that in very many of the diseases to which a vegetable origin is assigned, the blood affords evidence of considerable leucocytosis. Now, in as far as our observations go, such a process is incompatible with the simultaneous development of bacteria in the same specimen of blood; we have, indeed, on a former occasion, whilst referring to a similar subject, expressed the opinion that "the numbers present appeared to bear an inverse ratio to the number and activity of the bioplasts.§" Bacteria on being introduced into the circulation rapidly disappear from the blood unless death ensues, and all the phenomena appear to indicate that, so long as the leucocytes are in a state of activity, the former are worsted in the struggle for existence. Only when the activity and multiplication of the leucocytes cease, and coincident with the occurrence of disintegrative changes in their substance, do bacterial elements begin to appear and multiply. At this time, however, their development may be very rapid, and appear more rapid than it really is, owing to the difficulty of distinguishing between the granular *débris*—the

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* The *Medical Times and Gazette*, Vol. I, 1873, p. 62.
† Virchow's Archiv, 1862.
‡ Comptes Rendus, T. LVII, page 351, August 10th, 1863.
§ Appendix C, page 197, *Eighth Annual Report of Sanitary Commissioner*, 1872.

"granulations moléculaires"—of the leucocytes, and the elements of the independent organisms. A process in which living leucocytes are attacked and destroyed by bacteria has, however, in so far as we know, not yet been observed, far less has one in which the presence of bacteria first induces leucocytosis and then destroys the resulting cells.

Bacteria as a result of *ante-mortem* changes.

Most of the diseases which have been ascribed to bacterial agency are very severe and frequently fatal in their nature, and herein a possible source of fallacy is involved. In cases in which a fatal termination is rapidly impending, partial death affecting the elements of fluids and tissues to a greater or less degree may precede general death of the organism—the sum of the deaths of its constituent elements—and in such cases changes usually observed after the death of the organism, may take place in such fluids and tissues; so that, even in cases in which bacteria are found in the blood or other fluids *ante-mortem*, they may merely be the results of the advanced degree of the diseased condition, not the causes of its development.

This may probably be the explanation of the phenomena observed in inflammatory fluids and in the blood in cases, such as those already more than once referred to, in which the diseased condition was demonstrably due to chemical agency, as well as of many others in which similar phenomena may occur.

The question of the multiplication of disease-poisons.

It is possible that all the diseases ascribed to vegetable parasites may in reality be due to the influence of such organisms, but the proof of it has yet to be produced, and it is no real advance to ascribe them to such an origin on insufficient ground. This theory has attractions for many, on account of the apparently simple explanation which, if true, it would afford of the multiplication of disease-poisons. But, even allowing that such a multiplication could only take place under the influence of living matter and not as the result of any mere chemical process, it must always be borne in mind that the manufacture of the poison must, in any case, occur under the influence of multitudes of living cells and particles, cells and particles which may be just as capable of elaborating such poisons as vegetable organisms or other living matter introduced from without.

PART II.

ADDITIONAL EXPERIMENTS ON THE INTRODUCTION OF CHOLERAIC AND OTHER ORGANIC FLUIDS INTO THE SYSTEM.

Experiments on small animals liable to mislead.

As so much of the evidence placed on record relating to the existence of a specific virus in choleraic discharges has been based upon experiments which have been conducted on lower animals, it was resolved that the opportunities for repeating such experiments which Calcutta affords should be sedulously utilised in order, if possible, to settle the question for once and for all. The fact that the animals usually subjected to experiments of this kind have been of a very fragile constitution, accounts for a considerable amount of the discrepancy which exists between the statements made as to the effects of various septic influences upon them and the conclusions derived from these effects by various observers. In relation to the same question, and that from every-day experience indeed, we have no hesitation in saying that the inferences which have been deduced from experiments on septic poison conducted on such animals as rabbits, mice, and guinea-pigs, are untrustworthy in the highest degree.* That implicit reliance, however, is, very generally, placed upon the result of experiments obtained by feeding delicate animals with choleraic discharges is evident from some of the statements contained in the Report which has just been issued by the Vienna Cholera Conference. In one place it is mentioned that " les expériences de M. Thiersch à Munich ont prouvé que de petits morceaux de papier imbibés dans les selles des cholériques étaient capables de produire les formes du choléra." We ourselves attempted carrying out a series of observations on such animals, but found the results so hopelessly contradictory that we determined on resorting to others of more robust

* In reference to similar experiments and conclusions regarding *Charbon*, M. Sanson remarks : " Je craindrais de trop forcer les analogies en concluant des petits rongeurs aux ruminants, et je ne crois pas me tromper en disant que la cause des dissidences que se produisent sur la question est dans cette consideration".—Comptes Rendus, Tome LXVIII, page 341.

constitution, even though in many ways they might not be so manageable.*

We have already recorded a considerable number of such experiments, and trust that the evidence deducible from them and those now about to be referred to will be deemed sufficient to settle at all events some of the points so strongly debated at present in connection with the causation of disease.

Anæsthetics resorted to in all the experiments on animals.

We have in this, as in the former series of observations, selected the pariah dog as the most suitable and readily attainable animal, and need scarcely add that the precautions then taken not to inflict unnecessary pain have been strictly adhered to; anæsthetics being administered whenever any experiment which could prove painful had to be undertaken, and the animals kept under their influence as long as the experiments lasted. Such of the animals as it was deemed necessary to destroy were invariably placed under the influence of chloroform and not permitted to awaken, so that they certainly met with their death in a less painful manner than would otherwise have been their fate; for, sooner or later, they would have fallen into the hands of the men employed in diminishing the number of the dogs prowling about the streets.

Not deemed necessary to give individual experiments in detail.

Having on a former occasion given somewhat fully the details of numerous experiments, we do not deem it necessary again to repeat in detail for each case the various steps which were taken, but shall describe the experiments in as concise a manner as possible, as the copious notes which have been accumulated, although of value to ourselves in forming an opinion as to the lesson which each observation conveys, would only be tedious to the reader, and unnecessarily add to the length of our report.

The number of observations upon which the conclusions are based.

In our summaries of each group of experiments we shall include the data already published, and thus epitomise the results of all the experiments bearing on this

* That it is not without some show of reason that we place but little confidence in the results of experiments with such delicate animals is evident from the following remarks by Professor Parkes, in his Report on Hygiene for 1873, which has reached us since this paper was in the press. Dr. Parkes states, in reference to the very experiments cited at the Vienna Conference, that Professor H. Ranke of Munich had found that filtering paper *unsoiled* with the discharges produced injurious effects on mice.—Army Medical Report, Vol. XIV, 1874, page 253.

subject which we have conducted—results based on careful and more or less prolonged observations of the effects produced by septic agents on some two hundred animals, forming, if we be not mistaken, a more extended series than any yet recorded, and certainly one conducted upon a greater number of animals likely to yield more trustworthy data.

A.—Experiments on the injection of Choleraic and other Organic fluids into the Veins of animals.

In continuing this set of experiments, we had the following objects in view:—

1*st.*—To supply a deficiency in our last report, for which at that time we expressed our regret, *viz.*, "that the experiments on perfectly fresh choleraic material were not more numerous."

2*nd.*—To confirm or modify our inference that the observations then recorded did not afford "any evidence in favor of the existence of a specific poison contained in choleraic excreta, peculiar to them alone, and giving rise to special phenomena when introduced into the system."

3*rd.*—To accumulate a sufficient number of such experiments as to warrant our drawing something like definite conclusions as to the difference in *degree* between the toxic influence of choleraic as distinguished from normal alvine discharges.

4*th.*—To test to the utmost the influence of bacteria in these processes. The questions regarding the influence of bacteria on disease, as well as those relative to the origin of such organisms, have been referred to by an able writer as directly facing us, and as likely to hamper us in the course of farther inquiries until disposed of.* In so far as the morbid processes specially considered in the present report are concerned, we trust that the question regarding the influence of bacteria in the causation of disease has been satisfactorily determined, and we believe that the allied question as to whether or not the introduction into the system of *living* bodies of *any* kind is necessary for the production of the particular morbid phenomena under consideration, is also disposed of. With regard, however, to the ultimate origin of bacteria, we have not yet been able from our own observation to come to any final conclusion.

5*th.*—Lastly, to ascertain whether the product resulting from lesions thus produced invariably possesses the property

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* "British Medical Journal," 14th February 1874, page 208.

of reproducing the phenomena in a more marked or even equal degree.

These questions will be severally referred to after the narration of the experiments, as it will be more convenient to discuss them when the data upon which the conclusions are based are fully expressed and tabulated :—

1.—Experiments on the introduction of normal alvine solutions into the veins of dogs.

TABLE XII.

(*a*).—*The material introduced being* Fresh *and Not subjected to* Heat.

Experiment No.	Vein selected.		Quantity injected.	Affected.	Remarks.
	Femoral.	Saphena.			
I	1	...	Two drachms ...	...	The temperature did not exceed 102° F.
II	1	...	Four drachms ...	...	Urine highly colored on the second day, sp. gr. 1020; no albumen. On the third day temperature = 103°; on the 4th 103°; on the 5th 103°; the sp. gr. of urine on the last day being 1035; no albumen; no sugar. Before the experiment was commenced the temperature of this dog was 104° F. in the rectum.*
III	1	...	Five drachms.		
IV	1	...	Four drachms ...	1	The dog died in three hours, but no special *post-mortem* lesions could be detected.
V	1	...	Four drachms.		
VI	1	...	Six drachms ...	...	*Post-mortem* examination showed mesenteric glands somewhat affected, but nothing further.†
VII	...	1	Seven drachms ...	...	This dog had been subjected to a similar experiment previously.
VIII	...	1	Seven drachms.		
Total ... 8	6	2	... ...	1	

* With reference to the high temperature frequently recorded in apparently healthy dogs, it should be borne in mind that this is probably owing to the high temperature of the fermenting fæcal matter in the rectum—the rectum should therefore, when possible, not be selected for the application of the thermometer.

† The result of subsequent microscopical examinations of the organs and tissues of this and of other animals are referred to under separate headings.

Result of introducing ordinary excrementitious matters into the circulation.

We have somewhat reversed the arrangement of our tables on this occasion, so as to be able at starting to show what the result of introducing solutions of ordinary excrementitious substances into the circulation is, and to ascertain approximately the average proportion of definite results to be obtained from such a proceeding, before referring to the effects of similar material obtained from choleraic patients.

Mortality from FRESH solutions = 8 per cent.
Mortality from PUTRID solutions = 35 per cent.

It will be seen that we have added eight observations to the four recorded in our previous report, in which perfectly fresh solutions of alvine discharges had been prepared. Of these eight, one died; but of the four previously recorded, not one. Consequently, the mortality from the introduction of such a material (excluding of course such accidents as embolism, &c.) may be referred to as averaging about 8 per cent. The mortality resulting from the introduction of putrid material is, however, as we have previously shown, considerably higher; for out of seventeen animals thus treated, six died apparently from the toxic influence of the solution introduced: thus yielding a mortality of something like 35 per cent.—the period most fatal being when the material was from three to four days old.

Varying susceptibility of animals to septic influences.

Showing, however, the fallacy of being entirely guided by averages in matters of this nature, and apparently exemplifying the idiosyncrasies of animals in their susceptibility to septic influences, are the facts that the mortality resulting from the introduction of *boiled* solutions of fresh alvine discharges was greater than was yielded when the same material was unboiled, and that the same fluid in some cases produced a result, but in others did not. This appears to be the interpretation of the results shown in the table given on the next page:—

TABLE XIII.

(b).—The material introduced being Fresh, *but subjected to* Heat.

Experiment No.	Vein selected.		Temperature.		Number of drachms injected.	Affected.	Remarks.
	Femoral.	Saphena.	Degree.	Duration.			
IX	1	...	212°	3 minutes	Four	...	Continued depressed for a couple of days, but otherwise showed no symptom of illness.
X	1	...	212°	3 minutes	Four	1	The dog died during the night, having passed copious, sanguineous, liquid evacuations. The intestines were coated with a sanguineous exudation.
XI	1	...	212°	3 minutes	Six.		
XII	...	1	212	3 minutes	...	1	Vomited frequently during the day, and was greatly purged. Died in 8 hours. Mucous surface of intestine extremely congested. The evacuations exhaled a fishy, mawkish, choleraic odour.
XIII	...	1	212°	3 minutes	Six	...	This dog appeared to be in no way affected, although the material used was from the same vessel, and the experiment performed at the same time as the dog in Exp. XII.
XIV	...	1	212°	3 minutes	Six	...	The animal used in Exp. V (Table XII) again subjected to similar treatment. No result.
XV	...	1	212°	5 minutes	Five.		
XVI	...	1	212°	3 minutes	Seven.		
XVII	...	1	212°	3 minutes	Four.		
Total ... 9	3	6	...	.....	...	2	

TABLE XIV.

(c).—The alvine solution introduced having become Putrid: Heated shortly before use.

Experiment No.	Vein selected.		Temperature.		Number of drachms injected.	Affected.	Remarks.
	Femoral.	Saphena.	Degree.	Duration.			
XVIII	...	1	212°	3 minutes	Six	...	This dog had been subjected to somewhat similar treatment previously, without result.
XIX	...	1	212°	3 minutes	Four	1	Died within 12 hours. The same fluid used as in Exp. XVIII, the principal *post-mortem* lesion appeared to be embolisms in the lungs.
XX	...	1	212°	3 minutes	Four	...	The same fluid as in Exp. XVIII and XIX, Table XIV.
XXI	...	1	212°	4 minutes	Seven	...	Ditto ditto ditto.
Total ... 4	...	4	...	...	...	1	

With reference to the effect of boiling on the toxic properties of alvine discharges, nothing very conclusive can be inferred from the observations summarised in the two foregoing tables. It is important, however, to observe that the intestinal canal in at least two of the animals experimented upon was seriously affected, in consequence of the introduction of *boiled* alvine discharge from a healthy person.

The probable influence exerted by heat on such substances will be subsequently referred to; meantime it may be stated that, to the extent applied in the foregoing experiments, it certainly does not appear to diminish or modify their toxic properties.

2.—Experiments on the introduction of choleraic alvine discharges into the blood of dogs.

Twenty-three experiments with fresh choleraic excreta.

The want of a sufficient number of experiments on perfectly fresh choleraic excreta, which we have previously referred to as occurring in our last report—an omission regarding which more than one distinguished writer has expressed his regret—will, we trust, be considered as satisfactorily made good by the publication of the following account of twenty-three

experiments on as many dogs. In ten of the experiments the material injected into the blood was simply strained, and in thirteen the fluid was first subjected to heat, then allowed to cool and strained before being employed. A tabulated statement of the first-mentioned class of experiments is annexed:—

TABLE XV.

(a).—The Choleraic material introduced being Fresh *and Not subjected to* Heat.

Experiment No.	Vein selected.		Number of drachms injected.	Affected.	Remarks.
	Femoral.	Saphena.			
XXII	1	...	Four	1	The material injected consisted of almost colorless watery fluid. Death resulted in 5 hours without marked intestinal symptoms. Although the *post-mortem* examination was conducted within 2 hours after death, the stomach and intestines were enormously distended with gas: the intestinal glands could be seen very distinctly through the distended walls of the gut. The mucous surface was disorganised, and presented all the characters of acute septic enteritis; lungs collapsed; the splanchnic nerves and semilunar ganglia apparently unaffected.
XXIII	1	...	Four	...	Temperature at the time of the operation 102° in the vagina. Next day 104° in rectum, but 102° in vagina: appeared unaffected till the fourth day, when it was killed under chloroform. All the viscera were healthy. The bladder full of urine (sp. gr. 1012), and the intestinal contents quite normal.
XXIV	1	...	Four	1	The fluid injected was nearly colorless (sp. gr. 1004), and contained a few red blood-corpuscles. The dog died in about 18 hours. The intestines presented the appearance usual in gastro-enteritis. The blood was crowded with crystals, but not a trace of bacteria could be detected.
XXV	1	...	Two	...	On the second day the temperature was 104°5, on the 3rd 103°, on the 4th 104,° when the animal died. There were no special *post-mortem* appearances, except in the liver, where numerous minute embolic patches were visible and considerable softening. Death evidently due to embolism.
XXVI	1	...	Four	1	Death in 7 hours.
XXVII	1	...	Four	1	Death in 6 hours. The same material used as in Exp. XXVI.

(a).—The Choleraic material introduced being Fresh *and Not subjected to* Heat—continued.

Experiment No.	Vein selected.		Number of drachms injected.	Affected.	Remarks.
	Femoral.	Saphena.			
XXVIII	1	...	Four	1	Death within seven hours. The animal had not been purged, but the intestinal mucous membrane was much congested and softened.
XXIX	1	...	Four	...	Watched for 3 days; killed under chloroform; the intestines were found to be quite healthy.
XXX	1	...	Four	...	The dog escaped on the second day, apparently in excellent health.
XXXI	1	...	Four	...	Ditto ditto ditto.
XXXII	...	1	Six	1	Death within 12 hours, but no intestinal lesions present.
XXXIII	...	1	Eight	...	At first there was considerable depression, but by the next day the animal appeared tolerably well; secretion of urine abundant.
XXXIV	...	1	Four	1	Counter-experiments were made with the fluid used in these three experiments: seven dogs being under observation at the same time; three having been treated with unboiled material and four with the boiled.
XXXV	...	1	Four	...	
XXXVI	...	1	Four	...	
Total 15	10	5	...	7	

Difference in degree between the toxic properties of fresh choleraic and normal excreta.

It will be observed that the principal phenomena induced by the toxic material injected in these cases do not differ in their characters from those in which solutions of other decomposing organic substances were introduced into the system, hæmorrhagic gastro-enteritis being the leading feature recognised at *post-mortem* examinations: but we presume that some difficulty would be experienced in maintaining two opinions with regard to the *degree* of toxic properties exerted by resorting to solutions of fresh choleraic excreta, instead of to solutions of the same material derived from healthy individuals. This will become still more evident when the data furnished by the observation on heated choleraic material has been considered.

TABLE XVI.

(*b*).—*The Choleraic material introduced being* Fresh *but subjected to* Heat.

Experiment No.	Vein selected.		Temperature.		Drachms injected.	Affected.	Remarks.
	Femoral.	Saphena.	Degree.	Minutes' duration.			
XXXVII	1	...	212°	Three	Six	1	The dog died within 8 hours, and the *post-mortem* was conducted 1½ hour later. Intestines coated with soft gelatinous pinkish material, and the mucous membrane affected. Reddish serous-fluid in the pericardium.
XXXVIII	1	...	212°	Four	Four.		
XXXIX	1	...	212°	Three	Four	...	The same fluid used as in the last.
XL	1	...	212°	Three	Seven		
XLI	1	...	212°	Three	Four	...	The same fluid was injected unboiled without result in Exp. XXX, Table IV.
XLII	...	1	212°	Three	Six	1	Death within 6 hours after considerable purging. The small intestines contained watery fluid and numerous whitish flocculi. The mucous surface coated with a creamy layer, beneath which it was found to be extremely congested, and in some parts disintegrated. The large intestine also contained fluid.
XLIII	...	1	212°	Three	Four	1	This animal was treated in precisely the same manner as the last, with the same fluid and at the same time. Death took place here also within 6 hours. The symptoms had been the same, and the *post-mortem* appearances also, except that there was less watery fluid in the intestine.
XLIV	...	1	212°	Three	Eight	1	The animal was killed on the second day: there had been no very marked symptoms of illness, nor were there any marked lesions observed at the

(b)—*The Choleraic material introduced being* Fresh *but subjected to* Heat.—(continued).

Experiment No.	Vein selected.		Temperature.		Drachms injected.	Affected.	Remarks.
	Femoral.	Saphena.	Degree.	Minute's duration.			
							post-mortem examination, except that the last two feet of the small intestine had evidently been materially affected.
XLV	...	1	212°	Three	Eight	1	Died within 5 hours after having passed copious fluid stools and manifested symptoms of considerable pain. The material used was the same that was employed in the last experiment as also in Exp. XXXIII. Table IV, but in the latter case unboiled and with a negative result. A *post-mortem* examination was made immediately after death: the intestines were full of watery and slimy fluid. The venous blood was very dark: no bacteria could be detected in it.
XLVI	...	1	212°	Three	Four	1	Died within 12 hours. No very marked *post-mortem* lesion, the principal being peritonitis.
XLVII	...	1	212°	Three	Four	1	Died within 15 hours.
XLVIII	...	1	212°	Three	Four	...	Unaffected.
XLIX	...	1	212°	Three	Four	...	Not much affected.
							The fluid injected in the last four experiments was derived from the same patient, a well-marked case of cholera; and counter-experiments were made with it, without boiling, in three other dogs, two of which yielded no results. (Vide Exp. XXXIV—XXXVI, Table XV.)
Total 13	5	8	...	...	...	7	

The fresh choleraic material found to have affected 50 per cent.

Having on a former occasion discussed the nature of the lesions induced by the introduction of these varying solutions of decomposing organic matter, we do not consider it necessary to refer more definitely to them again, especially as the tables contain an abstract of the salient *post-mortem* appearances. In the present instance the question which we are desirous of testing is the *degree* of the toxic influence exerted by the various solutions.

It will be noted that in the foregoing two sets of experiments on choleraic material the mortality is considerable; in the case where heat was not employed fifteen cases, yielding positive results in seven, or equal to 46·6 per cent.; and in the other set, out of thirteen animals, seven were affected, or nearly 54 per cent.—the average number affected, of both combined, being exactly 50 per cent.

TABLE XVII.

(c).—The Choleraic material introduced having become Putrid.

Number of Experiments	Vein selected.		Drachms injected.	Material not heated.	Material heated.			Affected.	Remarks.
	Femoral.	Saphena.			Heated.	Temperature. Degree.	Minutes' duration.		
L	1	...	Four	1	...	...	...	...	The material injected was obtained from a *post-mortem* examination $3\frac{1}{2}$ hours after death. Previous to the operation the temperature of the dog was 101°; 13 hours after the operation 103°; from the second day to the sixth its temperature was 102° without any special symptoms being manifested.
LI	1	...	Four	1	...	...	...	...	The material injected was obtained from a *post-mortem* examination, but not from the same patient as the last. The dog died within 12 hours, but manifestly of embolism.
LII	1	...	Six...	1	...	...	...	...	The material employed here also was from the intestine of a patient 5 hours after death. The animal was not materially affected during the three days it was under observation.
LIII	1	...	Four	...	1	212°	Three	...	The same material used as in the last, but in this case boiled before straining.
LIV	...	1	Eight	...	1	212°	Three	...	The same material was used in Exp. LIV, LV, LVI on the first, second and third day after it had been obtained from a cholera patient. Only one dog was appreciably affected.
LV	...	1	Six...	...	1	212°	Three	...	
LVI	...	1	Six...	...	1	212°	Three	1	
LVII	...	1	Eight	1	...	...	...	...	The fluid employed as in Exp. LIV, LV, LVI, but unboiled.
Total 8	4	4	...	4	4	...	...	1	

Summary of results of experiments recorded in Tables XV–XVII.

The positive results recorded in the foregoing Table (No. XVII) are not so numerous as were the results obtained in our previous experiments with putrid material, or in those now recorded on perfectly fresh choleraic material. This, possibly, is owing to the comparatively few experiments that have been undertaken on this occasion. Of the eight animals experimented upon, only one was materially affected, and it so happens that in that case the material introduced had been subjected to a temperature of 212° F. a few minutes previous to being injected.

To sum up the results recorded in the tables of this section, showing the effect of the injection of choleraic alvine discharges into the veins of animals (Tables XV—XVII), it may be stated that of the thirty-six observations tabulated, fifteen yielded positive results, or somewhat less than 42 per cent. In nineteen of the experiments the material was not subjected to heat, and in seventeen cases the material had been heated up to 212°; the mortality from the former proved to be 36·8 per cent., and that of the latter 47 per cent.,—thus proving that heat applied to this extent, at all events, had not diminished the toxic influence of the substance experimented with.

Heat as a test of vitality, and as a disinfectant.

It is of very great importance to know definitely what is the effect of heat upon such organic substances as are known to be capable of manifesting virulent properties when introduced into the animal economy. This agent appears to us to offer a more trustworthy means than any other for ascertaining whether or not the active principle of these poisons is transmitted by infection with certain *vitalised* particles. In intimate relation to this subject, as recently pointed out by Dr. Bastian in his remarkably suggestive essay on "Heat and Living Matter," are many important questions with reference to the process of disinfection, "where we have to do with articles of furniture or wearing apparel used by a person suffering from a contagious disease. Because, in such a case, what we ought undoubtedly to know is whether the temperature of boiling

water or even of some lower temperature suffices to kill any living particles which may act as so-called 'germs of disease.' This is a subject upon which there should be no room for doubt."*

The application of heat to animal poisons.

We had hoped to have been able to have submitted on this occasion a series of experiments regarding the effect of heat upon the infecting principle in two undoubtedly contagious diseases—small-pox and vaccinia. The observations which we have commenced are not yet in a sufficiently advanced state to be published. We have, however, been able to satisfy ourselves to a certain extent with regard to the action of heat on another well-known animal secretion possessing most virulent properties, namely, Snake-poison.

Two series of observations on the effect of subjecting snake-venom to Heat.

Last April we were asked by Dr. Ewart, the President of the Snake Commission, to undertake some microscopic examinations of fresh virus of the Cobra and of an Australian snake.† In order to conduct these examinations, Dr. Vincent Richards caused several snakes to eject their poison into a watch-glass in our presence. The poisons from the two species of snakes were transferred into separate test tubes, having been previously diluted with about five parts of distilled water. Each sample was subsequently divided into two parts: One test tube, containing the simple aqueous solution of the virus, was set aside; the other test tube, containing the remaining half, was placed in a vessel of hot water and thoroughly boiled for ten minutes.‡ This proceeding enabled us to carry out two series of observations—(I) with unboiled and boiled aqueous solutions

* Contemporary Review, September 1874, p. 517.

† These microscopic examinations need not be specially referred to here, as the results are embodied in the report which has just been issued by that Commission. Suffice it to say, that we could distinguish no cells or organisms of any kind in the poison which were not equally present in the inert secretion obtained from the fauces of the snake. On several occasions, however, we observed that acicular feathery crystals had formed on some of the slides, and that numerous fusiform crystals were precipitated in the course of two days from the aqueous solution of the virus. All these will be found figured in the report referred to.

‡ On being placed in the warm water, the solution of virus in the test tube soon became turbid, and a flocculent precipitate was seen to form long before it had been heated to boiling point.

of virus obtained from the Cobra; and (II) with unboiled and boiled solutions of the virus from the Australian snake:—

SERIES I.—*Experiments illustrating the effect of Heat on the Virus of a Cobra.*

EXPERIMENT 1.—Injected 20 minims of the diluted virus (24 hours old) by means of a sub-cutaneous syringe into the thigh of a fowl. Died in 13 minutes 10 seconds.

EXPERIMENT 2.—Injected 20 minims of the diluted poison, previously *heated* to 212°F., into the thigh of a fowl—the poison 24 hours old. Died in 32 minutes 45 seconds. The symptoms in both cases were precisely the same.

EXPERIMENT 3.—Injected 20 minims of the diluted virus, not heated (48 hours old), into the thigh of a fowl. Died in 12 minutes 15 seconds.

EXPERIMENT 4.—Injected 20 minims of the diluted virus, heated to 212° (48 hours old), into the thigh of a fowl. Died in 44 minutes.

The solutions of the virus used in Exp. 3 and 4, having become 48 hours old, contained active bacteria; the boiled sample, however, contained far more than the unboiled.

All that remained of the virus used in the four foregoing experiments, now seventy-six hours old, was put into a single test-tube and still further diluted with distilled water. The tube was then partially submerged in hot water in a closed vessel and thoroughly boiled for ten minutes. The boiled solution exhaled a very offensive odour, something like putrid fish. This was filtered, and the clear fluid obtained used in the following experiment:—

EXPERIMENT 5.—20 minims of the above boiled and filtered solution of snake-venom were injected into the thigh of a strong fowl. The animal became drowsy in the course of half-an-hour, and subsequently presented all the symptoms manifested by the former animals, only in a milder degree. Died in 4 hours 43 minutes.

SERIES II.—*Experiments illustrating the effect of Heat on the Virus of an Australian Snake.*

EXPERIMENT 1.—Injected 15 minims of the unheated and unfiltered solution of the virus (quite fresh) into the thigh of a fowl. Died in 2 hours 16 minutes.

EXPERIMENT 2.—Injected 20 minims of a filtered solution of fresh virus (which had been heated to 212°F. as in Series I) into the thigh of a fowl. Died in 2 hours 23 minutes.

EXPERIMENT 3.—Injected 20 minims of the unheated solution of the virus (24 hours old) into the thigh of a fowl.

EXPERIMENT 4.—The same as Exp. 3.—Both fowls died within 24 minutes.

EXPERIMENT 5.—Injected 20 minims of a solution of the virus (48 hours old), heated to 212°F., into the thigh of a fowl.

EXPERIMENT 6.—The same as Exp. 5.—Both fowls were found dead 49 minutes after the introduction of the poison.*

Inferences regarding the intimate nature of snake-poison.

These experiments do not, as far as we are aware, differ materially in their results from those performed by Drs. Fayrer, Lauder Brunton, and others. From them it will be seen that heat applied in the manner and to the extent mentioned in the text does not materially modify the poisonous action of the virus of the snake. The heat resorted to was considerably more than sufficed to precipitate the fibro-albuminous material in it, and was, it may be presumed, sufficiently high and prolonged to destroy any protoplasmic bodies which it may have contained. The activity of the fluid did not seem to have suffered by being deprived of its fibro-albuminous constituents by precipitation and subsequent filtration; nor would the poison appear to be of a very volatile character.†

Taken altogether, these particular observations would seem to suggest that we should look to the chemist rather than to the histologist for further information regarding the nature of the active principle in the virus of the snake.

* In order to satisfy ourselves from personal observation that fowls are not particularly prone to succumb after the introduction of putrid animal matters into their tissues, a fowl was treated in precisely the same manner as the foregoing, except that 20 minims of a solution of highly putrid animal matter was substituted for the snake-venom. Apparently not the slightest effect was produced, and the bird escaped next day.

† After these experiments had been completed, we learnt incidentally that the attendant who had been instructed to throw the poisoned fowls away had in no single instance complied with this order, but had taken them to his own home, and that he and his family had eaten them. No evil consequences ensued.

B.—Experiments on the effect of transferring Inflammatory Products from a serous cavity of one animal to that of another.

The effect of transmission of inflammatory products from one animal to another.

With a view of ascertaining for ourselves whether an ordinary inflammation in one of the serous cavities would, as is so frequently stated, produce a fluid increasing in virulence by transfer from one animal to another, we have made seventy-three special observations on very nearly as many pariah dogs. It seemed desirable that the statement which has been so frequently advanced on this point should be tested in this country, especially as the procedure seemed to offer a favorable field for the discovery of some clue to one or other of the many inexplicable phenomena of cholera and other epidemics. These experiments have materially helped us in coming to a very definite opinion as to the connection of bacteria with inflammatory or other diseased states. Of the seventy-three, thirty-five were required in order to supply an inflammatory virus to test the virulence of the secondary and subsequent products. As the animals thus subjected to experiment were utilised in other ways, and are referred to elsewhere, it is not necessary to tabulate the individual experiments.

Primary inflammation induced in 60 per cent. of the experiments.

In eleven cases a purely chemical irritant (such as tincture of iodine and tincture of iron) was employed; and in the remaining twenty-four a solution of various excrementitious substances—a little tincture of iodine being added to the latter in two instances. Out of the eleven experiments just referred to, inflammatory exudation was obtained from seven; and from the other group of twenty-four experiments, a similar fluid was obtained in fourteen. It will therefore be seen that the results were positive in twenty-one out of thirty-five cases, or at the rate of 60 per cent.

The table on the next page will show the effect of transfering the morbid exudation thus obtained—whether injected when perfectly fresh, after a delay of twenty-four hours, or after being subjected to heat:—

TABLE XVIII.

Showing the result of injecting solutions of Inflammatory Products into the Peritoneal Cavity of animals.

Number of Experiment.	FLUID INTRODUCED ABOUT HALF AN OUNCE.			Affected.	Remarks.
	Not heated.		Heated to 212°.		
	Fresh.	1 day old.	Fresh.		
1	1	...	...	...	The fluid used in this experiment had been obtained from the peritoneal cavity of a dog in which peritonitis had been induced by the injection into its peritoneum of about an ounce of the watery contents of the small intestine of a man who had died of cholera. The second dog was in no way affected by the operation.
2	1	...	...	...	... ...
3	...	1	...	...	... ...
4	1	...	...	...	... ...
5	1	...	...	...	The fluid introduced in this instance was diluted, purulent matter, which had been obtained from an abscess which had formed in the subcutaneous tissue of the same dog.
6	1	...	...	...	
7	1	...	...	...	
8	1	...	...	1	Intense inflammation of peritoneum, pleura, and pericardium: death had occurred within 12 hours. The fluid originally injected had been obtained from the peritoneal cavity of a dog, in which peritonitis had been produced by the introduction of a solution of normal alvine discharge 24 hours old.
9	1	...	...	1	Death within 6 hours. The fluid which brought this about had been obtained from the dog in Exp. 8. Consequently, it was the third removed from the original irritant. The *post-mortem* appearances were the same as in the last.
10	1	...	...	1	Death within 5 hours. The fluid in this case was the fourth removed, having been obtained from the dog used in Exp. 9. Unfortunately our supply of animals ceased for a couple of days, so that we were unable to carry this series any further.
11	...	1	...	1	Peritonitis, pleurisy and pericarditis, with sanguineous fluid in the pericardial sac. The primary inflammation had been induced by means of a solution of normal alvine discharge introduced into the peritoneum of another dog two days previously.

TABLE XVIII—*continued.*

***Showing the result of injecting solutions of Inflammatory Products into the Peritoneal Cavity of animals*—continued.**

Number of Experiment.	FLUID INTRODUCED ABOUT HALF AN OUNCE.			Affected.	REMARKS.
	NOT HEATED.		HEATED TO 212°.		
	Fresh.	1 day old.	Fresh.		
12	...	1	...	...	The fluid used had been obtained from the dog in Exp. 11, and was consequently the second removed.
13	...	...	1	...	No effect beyond slight congestion of the peritoneum. The fluid injected had been strained subsequent to boiling.
14	...	...	1	...	The same fluid used as in the last, but it was not strained subsequent to boiling.
15	...	...	1	...	Fluid injected, obtained from the same source.
16	1	...	...	...	
17	1	...	...	...	Ditto ditto ditto.
18	1	...	...	...	Ditto ditto ditto.
19	1	...	...	...	Ditto ditto ditto.
20	1	...	...	1	The morbific agent obtained from the same source, a dog in which peritonitis had been produced by the introduction of a mixture of excrementitious matter from a former dog. Both animals died within 12 hours.
21	1	...	...	1	
22	1	...	...	...	The fluid resorted to was obtained from the peritoneal cavity of the dog in Exp. 21, and was therefore the second removed.
23	1	...	...	...	Precisely as in Exp. 22.
24	1	...	...	...	Fluid obtained from Exp. 20 : it was therefore the second removed.
25	1	...	...	1	Precisely as in Exp. 24 ; but in this case death resulted in 8 hours, with well-marked exudation on the peritoneum and in the intestines.
26	...	...	1	...	Precisely as in Exp. 22, but the fluid had been boiled.
27	1	...	...	...	The same fluid employed in these four Experiments: in Exp. 29 and 30, however, the material injected was 24 hours old.
28	1	...	...	...	
29	...	1	...	...	
30	...	1	...	...	
31	...	...	1	...	In both cases the fluid injected was obtained from the same animal.
32	1	...	...	...	
33	...	...	1	...	Ditto ditto ditto.
34	1	...	...	...	
35	1	...	...	...	The fluids employed in the foregoing four Experiments (31—34) mixed. No result.
36	1	...	...	...	The morbific agent obtained from the same animal in both cases. Both unboiled and boiled yielded negative results.
37	1	...	...	...	
38	...	1	...	...	
38	26	6	6	7	

Inflammation produced by peritonitic fluid in 18·4 per cent. of experiments.

The above Table shows that out of thirty-eight animals in which the product of peritonitis * was introduced into the abdominal cavity, only seven, or 18·4 per cent., either succumbed or were unmistakably affected—a considerably lower percentage than that obtained when solutions of ordinary excrementitious matters were used; for, of the animals experimented upon with the latter substances, about 70 per cent. succumbed.

The excessive virulence manifested by some inflammatory products.

The remarkable fact, however, appears that of the seven deaths referred to in the last paragraph, three were due to a virus obtained by inoculating from animal to animal in one series of experiments (in Nos. 8, 9, 10, Table XVIII), and, so far as we know, the number might have been unlimited had we at that time had a sufficient supply of animals to have carried on the observation without interruption.

In three others, out of the seven, we were unable to transfer the influence of the septic matter (contained in the decomposing substance resorted to in the first instance) to excite inflammation beyond the second animal; and in only one (out of several attempts) were we able to observe its toxic influence on a third. Whereas, in the three cases cited, four animals in succession rapidly succumbed to the effect of the virus contained in, or initiated by, a solution of ordinary alvine discharge.

This result cannot be attributed to mere idiosyncracy on the part of the animals in question; for not only in the experiments on peritonitic fluid has this phenomenon been observed, but in all cases where several experiments were carried out on the introduction of decomposing organic matter into the system. No matter by what channel they were introduced, certain solutions have manifested singularly virulent properties—properties which, hitherto, we have not been able to identify with any physical or chemical peculiarity.

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* It would be more correct to state that in thirty-seven instances the product of peritonitis was resorted to, as in one instance the fluid obtained was from an abscess which had formed in the abdominal walls, and which did not seem to communicate with the cavity of the peritoneum.

C.—Summary: With remarks on the probable Nature and relative Degree of Virulence of the toxic elements in Choleraic and Other Alvine Discharges.

Summary of observations detailed in this and in our former report.

The experiments just recorded agree in their general results in a marked manner with those which we have previously published, and quite bear out the inferences which we then felt justified in placing on record; but as the element of number is of such consequence in obscure questions of this nature, we have thought it advisable to bring together all the observations which have been detailed in this and in our former report, so that the lesson which it is possible for such a series of experiments to convey may be the more readily perceived.

TABLE XIX.

Total Experiments on the effect of the Introduction of Solutions of Organic Substances, from various sources, into the Circulation of Dogs.

Number of Experiments conducted.	Infecting material selected.	Where introduced.	Number affected.	Percentage of affected.
76	Solutions of choleraic evacuation ...	Vein ...	34	44·7
26	Solutions of normal evacuation ...	Vein ...	7	26·9
26	Solutions of various excrementitious matters	Peritoneum.	20	76·9
42	Peritonitic exudation ...	Peritoneum.	10	18·4

Comparative virulence of the various substances introduced into the veins.

From this table it will be seen that strained alvine discharges from persons suffering from cholera have been introduced into the veins of dogs on seventy-six occasions, with positive results in thirty-four, or at the rate of 44·7 per cent.

The result of a similar series of experiments with, by no means weak, solutions of normal alvine discharges (certainly not of lower specific gravity than the choleraic fluids) was not much over half that obtained from the former material; out of twenty-six experiments, in seven only were the animals affected, or at the rate of 26·9 per cent.

It appears from these results that the dejections of persons suffering from cholera, and also those of persons in good health, when injected into the veins, act in some cases as a poison—have the power of producing a definite effect on the intestinal mucous membrane, resulting in a disorganisation of its substance.

The symptoms and pathological changes induced by both varieties of material, the choleraic and non-choleraic present no differences : but, so far as our experience goes, the proportion of cases in which this result is attained when choleraic fluids are employed, is considerably larger than when non-choleraic material is used.

Comparative virulence of the various substances introduced into the peritoneum.

A closely allied phenomenon has been observed in connection with those experiments in which the material has been made to reach the circulation indirectly by means of the lymphatics in a serous membrane. We have, however, already touched on this subject in the paragraph referring to our experiments on the question of the increase in intensity of the virulent properties of inflammatory products as necessarily dependent on transference from one animal to another (page 50).

We have found that such an increase is by no means the ordinary result of the transfer—our experience being based on sixty-eight experiments; for, whereas the introduction of solutions of excrementitious matters into the peritoneum on twenty-six occasions was followed by serious inflammation and commonly death in twenty instances, or nearly 77 per cent. of the cases, similar experiments in forty-two cases with the fluid product resulting from snch primary inflammation was only successful in ten, or 23 per cent.

With two specimens of exudation only were we able to transfer the morbid action more than twice—once in the present series of experiments and once in the former—but on those two occasions the virulent properties manifested were unmistakable. In one case the original irritant employed was a decomposing solution of meat, ninety-six hours old, and in the other a solution of ordinary alvine discharge.

Conclusions.

Why the material, whether choleraic or non-choleraic, should exert its power in some instances and not in others, or why choleraic material would appear to possess this power more frequently than ordinary material, we cannot explain; but we are inclined to believe that the possession of these toxic properties will be found to depend on some variation—it may be only a trifling variation in composition which decomposing organic substances undergo. Something, however, is present which, as we have already said, is capable of exercising a singularly pernicious effect on animal life, the most prominent local manifestation of its action being observed in the intestinal canal.

What is this something? Is it visible? Is it a living substance?

With regard to the first of these questions, we would not presume to speak decisively, although we ourselves have searched for it in vain with lenses which have the reputation of being the very best hitherto constructed, and have been uniformly unsuccessful in associating it with any constant visible phenomena.

With regard to the second question, the reply will be satisfactory, or otherwise, according to the particular view entertained as to what the tests of vitality are. On this vexed question we do not venture to offer an opinion—whether, for example, any substance or condition which would cause the coagulation of albumen (animal and vegetable) would or would not be sufficient to destroy the vitality of the entity, be it 'egg,' 'seed,' 'germ' or 'plasma,' we cannot say. This, however, we affirm that in our own experience we have seen no living object preserve its vitality after exposure in a fluid to a temperature approaching to 212°F., nor have we been able to satisfy ourselves that any one else has done so.

A reference to the Tables of Experiments will show that the application of heat up to boiling point did not, apparently, modify the toxic properties of the particular substances tested; for out of seventeen instances in which choleraic alvine discharges were thus treated before introduction into the veins of dogs, eight became affected, or 47 per cent.—a slightly larger percentage than the unboiled fluids had yielded; and out of thirteen cases in which ordinary alvine

discharges had been similarly experimented with, three were affected, or 23 per cent.—some two or three per cent. lower than had been the average when the unboiled material had been resorted to.

Therefore, until it be proved that living substances can withstand immersion in a fluid at a temperature of 212°F. of some minutes' duration, we have no hesitation in stating that the morbid phenomena which we have observed to follow the introduction into the animal economy of strained solutions of choleraic and normal alvine discharges, and of other decomposing animal substances, are not the result of infection with a material the poisonous properties of which are dependent on its possessing vitality.

PART III.

EXPERIMENTS ON THE SECTION OF THE SPLANCHNIC AND MESENTERIC NERVES.

Sections of Mesenteric Nerves.

After the issue of our last report, an additional series of experiments regarding the effects of nerve-sections was carried on, with the view of finally satisfying ourselves whether any destruction of epithelium or denudation of the mucous membrane were necessary for the occurrence of a copious effusion of fluid into the intestinal tube, and also whether the observations which we had previously made regarding the coincidence of such effusion with partial but not with total deprivation of nervous supply, would stand the test of repeated experiments.

The following table shows the result of twenty-one experiments on section of the mesenteric nerves :—

TABLE XX.

Table XX.—Sections of Mesenteric Nerves.

No.	Nature of operation.	Result.
1	Complete section of nerves of a loop of intestine.	Exudation of watery fluid. Loop half-full of fluid, and containing some loose mucous flocculi.
2	Section of mesenteric nerves ...	Loop distended with grey watery fluid containing gelatinous flocculi. Surface of mucous membrane soft, thickened and covered with a gelatinous layer of material similar to the flocculi. Fluid strongly alkaline; smell mawkish and choleraic; contained about $\frac{1}{3}$th of albumen. Flocculi composed of exudation cells. Gelatinous layer on mucous membrane composed of similar cells in a mucoid basis.
3	Section of mesenteric nerves ...	Exudation of fluid; reddish; sp. gr. 1,009; alkaline; containing albumen.
4	Section of mesenteric nerves ...	Loop distended with fluid; pinkish grey; strongly alkaline; odour choleraic; sp. gr. 1,006. Surface of mucous membrane soft, thickened and covered with a loose yellowish layer of exudation cells.

Table XX.—Sections of Messenteric Nerves—continued.

No.	Nature of operation.	Result.
5	Section of mesenteric nerves ...	Mucous membrane soft, moist and thickened, but no exudation. The ligatured loop was situated in the jejunum.
6	Section of mesenteric nerves ...	Loop fully distended with fluid; reddish; sp. gr. 1,005; alkaline; containing a few flocculi.
7	Section of mesenteric nerves ...	Loop fully distended with fluid.
8	Section of mesenteric nerves ...	Loop contained an abundance of fluid. It was situated in the jejunum.
9	Complete section of mesenteric nerves.	No fluid in the loop.
10	Section of mesenteric nerves ...	Fluid exudation.
11	Section of mesenteric nerves ...	„ „
12	Section of mesenteric nerves ...	No special exudation in the centre loop.
13	Complete section of mesenteric nerves.	Loop full of brownish gelatinous exudation containing numerous large bioplasts.
14	Complete section of mesenteric nerves.	Abundant exudation of fluid.
15	Complete section of mesenteric nerves.	Loop almost empty.
16	Complete section of mesenteric nerves.	Loop fully distended with fluid; straw colored; alkaline; sp. gr. 1,008.
17	Complete section of mesenteric nerves.	Loop fully distended with fluid; alkaline; containing an abundance of granular exudation cells.
18	Complete section of mesenteric nerves.	Loop distended with fluid, swarming with bacteria and vibriones. *Post-mortem* some hours after death.
19	Complete section of mesenteric nerves.	Loop distended with fluid. Mucous membrane thickened and moist.
20	Complete section of mesenteric nerves.	Loop fully distended with fluid, watery, almost colorless; sp. gr. 1,005; reaction alkaline. A few projecting flocculi containing exudation cells on the surface of the mucous membrane.
21	Complete section of mesenteric nerves.	No special exudation in the ligatured loop.

Copious secretion of fluid in the intestines as a result of section of mesenteric nerves.

It will be seen that a copious secretion of fluid was the almost invariable result of section of the nerves, entirely independent of detachment of the epithelial covering of the mucous membrane, but sometimes associated with the occurrence of an exudation of bioplasts upon its surface; and that the secretion occurred as well in cases in which the division of the nerves was complete as when it was only partial. These results are similar to those obtained by us in the greater number of the experiments of this nature which we referred to on a former occasion, and are quite in accordance with those obtained originally by

Moreau. Moreau's experiments have also been confirmed by Dr. Lauder Brunton. Those of the cases in our report for 1872 in which complete division was found to be unaccompanied by an abundant secretion, must, therefore, be looked upon as accidental; and, from extended experience, we would incline to ascribe the occurrence to incompleteness in the isolation of the ligatured loop, or to escape of the fluid owing to rupture of the gut as a result of ulceration at the site of ligature and of the pressure exerted by the contained fluid: both these accidents were more than once observed to have occurred and to have modified the results of the experiments accordingly.

Sections of Splanchnic nerves.

Only a few experiments on section of the greater splanchnic nerves were tried, as the results were entirely similar to those in the previous series of such sections. The following table shows the nature of the operation and the result in seven cases :—

TABLE XXI.

Table XXI.—Sections of the Splanchnic Nerves.

No.	Nature of operation.	Result.
1	Section of left greater splanchnic nerve; and excision of semilunar ganglion.	No result.
2	Section of left greater splanchnic; excision of semilunar ganglion; and ligature of rectum.	No result.
3	Section of both greater splanchnics.	Died 36 hours afterwards with dysenteric symptoms.
4	Section of both greater splanchnic nerves and ligature of rectum.	No result.
5	Section of left greater splanchnic and ligature of colon.	No result. Urine; sp. gr. 1,040; no sugar; no albumen.
6	Section of both greater splanchnics	No result.
7	Section of left greater splanchnic and excision of semilunar ganglion.	No result. Urine contained neither sugar nor albumen.

It appears from this that no result similar to that dependent on section of the mesenteric nerves can be induced by division of the splanchnic nerves, even when this is combined with excision of the semilunar ganglia.

CALCUTTA,
October 1874.

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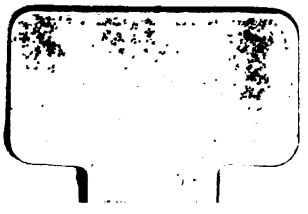

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REPORT

ON

MICROSCOPICAL AND PHYSIOLOGICAL RESEARCHES

INTO THE

NATURE OF THE AGENT OR AGENTS PRODUCING

CHOLERA

(SECOND SERIES)

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